(12)

ARI TECHNICAL REPORT TR-78-A1

COMPUTERIZED COLLECTIVE TRAINING FOR TEAMS

FINAL REPORT

By

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SENSORS, DATA, DECISIONS, INC

Prepared for

U.S. ARMY RESEARCH INSTITUTE for the BEHAVIORAL & SOCIAL SCIENCES
& DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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NOTICES

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

18 ARI

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 19 TR-78-A1
2. GOVT ACCESSION NO.: ✓
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): 6 Computerized Collective Training for Teams. Final Report.
5. TYPE OF REPORT & PERIOD COVERED: 9 Final rept. 30 Aug 76-18 Oct 77,
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): 10 Paul Thurmond a[redacted] H. Dewey Kribs
8. CONTRACT OR GRANT NUMBER(s): 15 DANC19-76-C-0042, ARPA Order-2887
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Sensors, Data, Decisions Inc. 5404 Linda Vista Road San Diego, CA 92110
10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS: 16 20762722A764, ~~I-764-B-2~~
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Research Institute for the Behavioral & Social Sciences (PERI-OK), 5001 Eisenhower Ave., Alexandria, VA 22333
12. REPORT DATE: 11 Feb[redacted]78
13. NUMBER OF PAGES: 98 12 109p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work was jointly sponsored by ARI and the Defense Advanced Research Projects Agency under ARPA Order 2887. Contracting Officer's Technical Representative was J. D. Baker, Educational Technology and Training Simulation Technical Area, ARI.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Team Training, Instructional Strategies, CAI, Collective Training, Small Group Training, Computerized Team Training, Team Training CAI, Computerized Crew Training, TACFIRE, Staff Training, Embedded Training, Team Training Instructional Strategies

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this investigation was to empirically demonstrate and evaluate a brassboard for computerized collective training for teams ($COLT^2$). The four tasks underlying the demonstration/evaluation were (1) conduct a state-of-the-art assessment of instructional strategies appropriate for $COLT^2$, (2) derive a conceptual framework for $COLT^2$ instructional strategies, (3) conduct a team job/task and training analysis for $COLT^2$ on the Army computerized artillery fire control system (TACFIRE), and (4) develop ow

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TACFIRE team training scenarios for the purpose of instructional strategy assessment. The procedures included design and implementation of a team ISD model, via which smaple training materials were developed. The materials were adapted to the team training version of the PLANIT CAI system. The COLT^2 brassboard was demonstrated at the US Army Research Institute for the Behavioral and Social Sciences, Arlington, VA. The results of the developmental aspects of the project indicate that many of the components of the team ISD approach that were designed for this effort would adequately meet the criteria for a generic team ISD model. Preparation of team learning objectives and evaluation of interactive team skills are deficient areas. PLANIT met the basic team CAI requirements. However, enhancement of the team training directives should be undertaken in order to (1) broaden the CAI base for instructional strategies, and (2) facilitate authoring procedures. Demonstration/evaluation subjects trained on the sample material in either a team or an individual mode. The results preliminarily indicate that there are differences in regard to what types of behavior are learned between team and individual instruction.

FOREWORD

The Educational Technology and Training Simulation Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research to support the development of training concepts and evaluation techniques for applying automation, simulation and training devices in a unit setting. A training concept currently under study is the use of automation, *viz.*, tactical computers, for training. Tactical computers have great potential for presenting individual and collective (or team) training. Individual training using the tactical computer has been developed and evaluated. The development of team training was an expressed priority of the recent Defense Science Board Report to the Director of Defense Research and Engineering. In anticipation of the Defense Science Board Report, the present Technical Report (and a previously issued companion report - ARI Technical Report TR-77-A4) reviews the problems of the development of instructional strategies for conducting team training and examines the potential of the computer for controlling and monitoring team training.

The research reported herein was jointly aponsored by ARI and the Defense Advanced Research Projects Agency (ARPA Order 2887), and is responsive to specific requirements of the U.S. Army Field Artillery School, the Training Support Center of the U.S. Army Training and Doctrine Command, and to Army Project 2Q762722A764. The work reported on here was performed by Sensors, Data, Decisions, Inc. under the technical monitorship of James D. Baker, Chief of the Educational Technology and Simulation Technical Area, ARI.

J. E. UHLANER,
Technical Director

COMPUTERIZED COLLECTIVE TRAINING FOR TEAMS

BRIEF

Requirement

Past research on team training has not focused, to any substantial degree, on establishing a methodology for developing team training curricula or on investigating the potential of computer technology as a delivery system for team training. The major purpose of this study was to develop an approach for designing team training scenarios and testing the feasibility of the team training version of the PLANIT CAI system as an instructional medium for scenario presentation.

The project objectives were as follows:

1. To determine from the existing literature, previous surveys, personal contacts and other related sources the information which exists with regard to state-of-the-art findings and instructional theory directly applicable to the problem of developing instructional strategies for computer-assisted team training.

2. To derive historically, analytically and/or empirically a conceptual framework, fleshed-out with detailed principles, for a general purpose (non-job or system specific) set of instructional strategies applicable to team training problems in a computerized setting.

3. To conduct a detailed job/task analysis for two classes of team training: (a) the man-computer-man paradigm, and (b) the man-(non-computer)-man setting.

4. To develop an appropriate scenario representative of and permitting the assessment of the job/task analysis and which will permit the insertion of objective 2 team training strategies into the scenario in order to make it a training scenario rather than a purely drill and exercise vehicle.

5. To construct, demonstrate and evaluate a "brassboard" team training system which ties meaningful aspects of all project findings together.

Procedures

Building on an empirical and theoretical base established in prior research, a conceptual framework for deriving team training instructional strategies was developed. In turn, generic individual instructional systems development (ISD) techniques were adapted to a team training ISD model. The model was utilized to derive the team training specifications for a segment of the U.S. Army's computerized artillery fire control system, TACFIRE, operations. On the basis of these specifications, sample training materials which reflected a selection of team instructional strategies were developed and adapted to the team training version of the PLANIT computer assisted instruction (CAI) system. The 'brassboard' of computerized collective training for teams ($COLT^2$) was demonstrated and evaluated at the U.S. Army Research Institute for the Behavioral and Social Sciences in Arlington, VA.

Findings

Team operations occur in a situational context which is a continuum; the end points of which are described as established or emergent. An established situation is one for which performance requirements are specifiable, predictable, and comply with standard operating procedures. In an emergent situation, the environmental conditions during the performance requirements are unanticipated, and the state of the system does not comply with standard operating procedures. Teams operate along this continuum in either serial or parallel. Serial activities are sequential with the input for one team member based upon the output of another. Parallel team structures are characterized by team members performing the same or interrelated tasks simultaneously.

Team instructional strategies are defined as the product of a series of decisions which provide for the structuring of learning activities by three types of information: (1) the nature of the task to be learned, (2) the characteristics of the learner and learner strategies, and (3) the capability of the instructional delivery system. Underlying the development of team instructional strategies, there is needed a team ISD model by which the specifications of the instruction can be derived. The model should identify team task dimensions, team objectives, and the scope and sequencing of specific learning events for both established and emergent contexts and for both serial and parallel structures.

Team training scenarios are task and environment specific in nature. That is, there must be adequate incorporation of team task interactions in the instructional strategies underlying the scenario. Then the team interactions must be placed in a simulated tactical environment. Rich combat representations built into the scenarios may be critical in order to involve a $COLT^2$ trainee at more than a drill and practice level.

The team version of PLANIT adequately provided for the four major team CAI considerations: (1) multi-person initialization of lessons, (2) communication among team members, (3) synchronization of team members and scenario events, and (4) manipulation of a common data base for storing and retrieving scenario-related information. Enhancements are required to increase the speed of the operating system, to provide greater flexibility in communications, and to facilitate authoring procedures.

The results of the demonstration/evaluation, while limited in inferential power due primarily to the small number of subjects and the anecdotal nature of the evaluation, indicate that there are differences between the effectiveness of team and individual instruction in regard to what types of behavior are being learned. Supporting this claim are the following observations:

1. The coordinated (team) training did not seem to increase individual skills as well as continuous individual training,

2. There appears to be little stability among independent variables for explaining variance in subject scores between individual and team contexts, and

3. Coordinated behavior lends to better achievement on specific tasks.

Utilization of Findings

The findings of the study impact on three team topics: (1) the development of a team ISD model, (2) requirements for a team CAI system, and (3) requirements for team training research. Recommendations for future developmental efforts are suggested for each topic.

Generally, the team ISD approach as designed and implemented was insufficiently fleshed out to serve as a step-by-step procedural guide for developing team training. Deficiencies include (1) a methodology for preparing, analyzing, and categorizing team learning objectives, (2) evaluation designs which would address team member interactions as well as individual and team achievement, and (3) the incorporation of applicable knowledge regarding small group behavior into the data base of the conceptual framework for COLT^2 instructional strategies.

Recommendations for the enhancement of PLANIT focused on software modifications that would improve system operations and flexibility and design modifications to facilitate authoring procedures. Recommendations for future research emphasized (1) investigating the relationships of team personnel composites, achievement, and modes of COLT^2, and (2) testing TACFIRE training scenarios in an operational setting.

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INTRODUCTION

Team training has been an active topic in Department of Defense and Civilian Sector training research arenas for over two decades. Research projects addressing the subject have been extensive and have identified many problems whose resolution is critical to effective team functioning. Yet to date, R&D efforts have neither resulted in the establishment of a methodology for developing team training curricula or, to any substantial degree, investigated the potential of computer technology as an effective and efficient delivery system for team training.

With the advent of complex computer-based weapon systems which necessitate coordinated actions of multiple operators and decision makers, team training of system users has become a critical need. Recognition of the problem by the Army has led to the initiation of related research projects by the U.S. Army Research Institute (ARI) and by the Defense Advanced Research Projects Agency (DARPA). Further, the ARI research which is currently focused on the use of computerized tactical data systems as a major individual training medium is being extended to include investigations of the feasibility and effectiveness of embedding team training on the Army's computerized artillary fire control system, TACFIRE.

The project final report which follows provides the results of the design and application of a team instructional system design (ISD) methodology in the development of <u>co</u>mputerized <u>col</u>lective <u>t</u>raining for <u>t</u>eams ($COLT^2$). In essence, the design of the team ISD model involved extending generic individual instruction systems design concepts to encompass team training aspects and subsequently developing a computer assistance instruction (CAI) team training brassboard based on the team ISD approach. Thus, the methodology directly relates existing knowledge regarding various dimensions of individual and team training to the

development of a specific team computer-assisted instruction brassboard. In turn, the brassboard reflects a sampling of instructional strategies which account for three critical components of team training: (1) team task dimensions, (2) individual learner characteristics, and (3) CAI capabilities.

The COLT^2 lessons developed and evaluated were designed to address a specific operational Army team, an artillery battalion TACFIRE Fire Direction Center team composed of a fire direction officer (FDO) and a fire direction sergeant (FDS). The team training issues which emerged during the course of the project are not, however, delimited by the specific team environment being dealt with, but rather are generic to the preponderance of military team training. The issues are complex and make it clear that a single team training methodology without flexibility will not suffice as a derivator of team training requirements and as a guide to the development of effective team instruction.

It is our belief that the team training approach demonstrated in this project embodies the comprehensiveness required of a team ISD model and possesses the flexibility required for application to a broad range of team environments. The conceptual structure of the project, with the supporting empirical data, indicates that the representation of the intersection of team task dimensions, individual learner characteristics, and instructional delivery system in instructional strategies is critical to effective team training. In turn, the methodology proved effective in deriving team task dimensions and as a guide for team curricular materials development. The methodology, however, is far from being fleshed out in detail or from being adequately tested.

Organization of Final Report

The remainder of the Final Report is organized as follows: The introduction presents a brief description of the TACFIRE training research which leads up to this effort, and a listing of the specific tasks undertaken

in the present project. The second section contains an overview of the fundamental issues underlying team training and their implications for developing team training programs. The third section provides a discussion of a conceptual framework from which $COLT^2$ instructional strategies may be derived. Primarily, the three critical components of $COLT^2$ instructional strategies--team task dimensions, individual learner attributes, and CAI capabilities--are reviewed. Section four provides a description of the brassboard development. The major focus is on describing the results of implementing the team ISD model and the development of the training scenarios.

The results of the brassboard demonstrations are documented in section five. The sixth section is a discussion of overall project findings. Section seven contains recommendations.

Background to TACFIRE Training Research

As part of a long range plan, ARI is engaged in an effort to maximize utilization of tactical data systems to meet tactical training needs. The first phase of ARI's effort toward using tactical systems in an instructional mode involved the MASSTER test 122 "IBCS: Automated Instruction" project. This project demonstrated the feasibility of using a prototype tactical data processing system in a stand alone mode to support unit training requirements. The instruction developed, however, was not related to training of system users.

The second phase of the ARI effort to employ tactical data systems for instructional purposes involved embedding training that was directly related to the operation of the tactical system itself. One benefit of embedded training is that it can provide training at the unit level and location, thereby reducing or eliminating the need to send personnel away to school. Embedded training also accomplishes general familiarization with the tactical

data system through a self-instructional mode. That is, personnel who are operators or who are involved in maintenance of a tactical data system are likely to have little experience with computers. Thus, instructional material embedded in the tactical data system offers an additional opportunity to become familiar with system equipment and operational characteristics.

In May 1975 ARI contracted with System Development Corporation for the development of embedded self-instructional programs for users of the TACFIRE system. The overall aim of the effort was to extend the scope of computer-assisted instruction to the development of self-instructional programs and procedures for TACFIRE users. The basic approach was to embed a training subsystem package within the operating TACFIRE system and to use the system itself to train personnel in its operation and maintenance. The training goals of the courseware to be used in the embedded mode were:

1. To present techniques to aid the users in learning how to operate the system.

2. To exercise and update system related skills.

3. To provide on-line situational problems which enable the users to exercise all the skills previously acquired (Hoyt, Butler and Leung, 1976.

TACFIRE courseware, using the PLANIT language, was developed and produced in five functional areas. The average course time for this individualized, self-paced, embedded training program is approximately 40 hours and covers an estimated 25 to 35 percent of the Battalion Fire Direction Center operations (Hoyt, et al., 1976).

The present project, initialized in August 1976, represents an extension of the scope of embedded TACFIRE training. The previously mentioned course-ware was designed to develop and maintain individual skills in operating the TACFIRE system. The objective of the present project is to demonstrate and evaluate training of TACFIRE system personnel operating as a team.

Team training is a function of the requirement for coordinated activity within the TACFIRE environment. As a computerized command/control system, TACFIRE has a number of characteristics that are common to all such systems. For example, the system is operated by teams of people whose interaction with each other in the environment is mediated by the computer complex with associated input/output requirements. Within this sophisticated and complex computer-based weapon system environment, it is essential for personnel to 'cooperatively' perform tasks. The division of individual responsibilities and the team member interactions require a broader training scope to be taken than currently exists. Therefore, the ultimate goal of this project is to investigate the feasibility of extending the concept of embedded CAI training beyond individual instruction to the training of teams.

Project Tasks and Objectives

The project tasks and objectives are listed below.

Task 1: State-of-the-art assessment of instructional strategies for computer-assisted team training. To determine from the existing literature, previous surveys, personal contacts and other related sources the information which exists with regard to state-of-the-art findings and instructional theory directly applicable to the problem of developing instructional strategies for computer-assisted team training.

Task 2: Derivation and development of instructional strategies for computer-assisted team training. To derive historically, analytically and/or empirically a conceptual framework, fleshed-out with detailed principles, for a general purpose (non-job or system specific) set of instructional strategies applicable to team training problems in a computerized setting.

Task 3: Job/task and training analysis for computer-assisted TACFIRE team training. To conduct a detailed job/task analysis for two classes of

team training: (1) the man-computer-man paradigm, and (2) the man-(non-computer)-man setting.

Task 4: Scenario development for instructional strategy assessment. To develop an appropriate scenario representative of and permitting the assessment of the job/task analysis and which will permit the insertion of Task 2 team training strategies into the scenario in order to make it a training scenario rather than a purely drill and exercise vehicle.

Task 5: Development and demonstration/evaluation of a "brassboard" computerized team training system. To construct, demonstrate and evaluate a "brassboard" team training system which ties meaningful aspects of all of the preceding Tasks together.

AN OVERVIEW OF MAJOR TEAM ISSUES

Team Definition

Task 1, a state-of-the-art assessment of instructional strategies for computer-assisted team training, had as its objective the determination of the applicability of findings of previous research efforts to the problem of developing instructional strategies for computer-assisted team training. In the undertaking of this task, the Project Team was quickly confronted with the complexity of team training issues and with the lack of unanimity within the research community regarding these issues. For example, two extensive reviews of team training (Hall and Rizzo, 1975; Wagner, Hibbits, Rosenblatt and Schulz, 1976) identified the difficulty in defining team and team training. As noted by Hall and Rizzo "no one seems to be able to articulate its [team] dimensions with sufficient clarity to permit the development of training procedures for producing it." It was further stated in this report that another major issue that lacks resolution was the determination of whether a team is simply a collection of individuals performing separate task jobs in a group context or if there are unique trainable team skills that exist over and above individual functions.

The first of these issues, that is, the definition of a team, was resolved by employing an existing description of a team. The description was based on observations offered by Klaus and Glazer (1968). They stated:

> The team is usually well organized, highly structured and has relatively formal operating procedures - as exemplified by a baseball team, an aircraft crew, or ship control team. Teams generally:
>
> (1) Are relatively rigid in structure, organization and communication networks.
>
> (2) Have well defined positions or numbers assignments so that participation in a given task by each individual can be anticipated to a given extent.

(3) Depend on the cooperative or coordinative participation of several specialized individuals whose activities contain a little overlap and who must each perform their task at least at some minimum level of proficiency.

(4) Are often involved with equipment or tasks requiring perceptual motor activities.

(5) Can be given specific guidance on job performance based on a task analysis of the team's equipment, mission or situation.

Thus the criteria for team definition include: (1) rigid structure, organization and communication networks, (2) anticipation of an individual's task participation by virtue of well defined assignments, and (3) cooperation and coordination.

Conceptual Team Models

The second major team training issue is related to the conceptualization of teams into two models. These models are referred to as "stimulus response" and as "organismic". Alexander and Cooperband (1965) distinguish between the two team training models based on situations in which the team behavior takes place. The stimulus response model was applied to teams which operate primarily in an established situation where tasks and the activities required to perform the operation can be completely specified and assignment of functions among team members and equipment is relatively rigid. In the organismic model, the team is considered to be a synthetic organism of which individuals are components. This model is oriented towards teams operating in an environment which includes a significant proportion of emergent situations. In emergent situations, there are defined task assignments; however, the individual has a considerable degree of discretion as to how to perform the task given various contingencies. Consequently, team performance depends on the development of appropriate team procedures for coping with environmental contingencies more

so than on individual job proficiency. Thus, adaptive innovations are required by team members, and decision making and problem solving skills are critical.

The two conceptual approaches take as their bases the situational contexts in which team behavior occurs. In actuality, the situational context is a continuum, the end points of which are described as established or emergent. Boguslaw and Porter (1962) define these situations as follows:

> An established situation is one in which (1) all action-relevant environmental conditions are specifiable and predictable, (2) all action-relevant states of the system are specifiable and predictable, and (3) available research technology or records are adequate to provide statements about the probable consequences of alternative actions. An emergent situation is one in which (1) all action-relevant environmental conditions have not been specified, (2) the state of the system does not correspond to relied upon predictions, and (3) analytical solutions are not available given current states of analytical technology.

The two conceptual viewpoints have also served as contexts for team training research. For example, investigation of team member interactions in an established situation was a primary focus of a team training laboratory program at the American Institute of Research (Klaus and Glaser, 1960). There are obvious advantages to the team training laboratory research, but the often necessary simplification of the team functions can mask or omit possible important variables which influence behavior in the real world. Abstracting the situational contexts in the laboratory can result in a loss of opportunity for trainees to react to breakdowns or problems which may arise in an operational setting (Wagner, et al., 1976).

Providing skills to deal with emergent unstructured situations was seen as a major goal of an earlier team training program (Alexander and Cooperband, 1965). The development of coordination skills was stressed although it was recognized that these are based upon attainment of minimum individual skills. In turn, team training devices and techniques were seen as requiring orientation

for training innovative behaviors and skills necessary to adapt to unforeseen problems. It was agreed that emergent situation training permits a more realistic, less abstract approach than established situation training. In the emergent case, what seems to be important is training team members to become fully aware of their responsibilities, to compensate for the inability of others, and to overcome temporary problems when the situation calls for it.

It is obvious that in actuality, no team operates in purely an established or an emergent situation. Therefore, in conducting the job/task and training analysis, emphasis was placed first on defining the precise TACFIRE established situation as prescribed by standard operating procedures and, secondly, on identifying the most common and critical emergent situations that impact actual operations of the TACFIRE system. By defining both the established and the emergent situations, the team member interactions which occur in both cases could be analyzed in order to determine the team task dimensions that are present.

Team Structure

A third major issue underlying the development of team training is related to the structure (interaction of team members) of team operations. Basically, teams function either in serial or parallel. In a serial or vertical structure, activities are sequential with input for one team member based upon output of another. Parallel team structures are characterized by team members performing the same or similar tasks simultaneously.

Research related to team structure and effectiveness has had mixed results. For example, Briggs and Johnston (1967) suggested that parallel team structures are preferable to serial structures because team performance in the parallel structure is not dependent on the least skilled member. On the other hand, Klaus and Glaser (1968) reported that the parallel structure led only to a

short term gain and eventually to a decrement in team performance. There is, however, one point of agreement. In a purely established situation the serial team structure results in better performance. In the same situation, parallel structures seem to inhibit or slow down team performances. On the other hand, in emergent situations, team failure is frequently a function of individual skill deficiency. Teams apparently respond more effectively to emergent tasks if a parallel team structure is in effect.

In a TACFIRE operation there is neither a pure serial nor parallel team structure. What commonly is the case is that more than one team member will receive similar inputs, but the responsibility for output is predetermined by standard operating procedures. In the event of emergent or contingent situations, more than one team member is prepared or should be prepared to address problems which arise.

Implications for Team Training

Each of the previously discussed issues should be taken into consideration by the developer of a team training curriculum. First, the definition of a team contains certain criteria which distinguish it from the multi-individual task context as well as a small group. Ultimately, it is these same criteria which serve as the foundation for developing and implementing a team ISD approach in order to derive instructional strategies for the training. For example, if the criteria of (1) a rigid structure, organization and communication network, (2) anticipation of an individual's task participation and (3) cooperation and coordination are not present to some degree, any other issues (i.e., the conceptual team model and team structure) are mute.

If there is no rigid team structure or standard operating procedure, it is not possible to determine an established situation for the team performance. On the other hand, if cooperation and coordination are not integral components

of the team's operations then emergent situations do not impact on the team as a whole but only on the individuals operating within the group context. Further, if there is not overlap within the individuals' task participation by virtue of the defined assignments, then the team operation will be in its purest sense "a stimulus-response" model and will, in effect, represent only a multi-person operation. The inverse of this situation is also true. That is, if there are no defined assignments related to specific task operations but all individuals are cooperatively addressing all tasks without defined structure and organization, then it is likely that the team is in fact a small group, should be defined as such, and the more general rules of small group behavior applied.

Once a team has met the criteria for definition as a team, the second and third major team training issues discussed begin to have a tremendous impact on the subsequent development of the training curriculum. Primarily, the connection is via the team job/task and training analysis. The team job/task and training analysis must be comprehensive enough to provide for the identification of both standard operating procedures tasks and unanticipated combinations of known tasks as well as the emergence of previously unaddressed and untrained to performance requirements. Thus, there is a direct tie from the team model to the establishment of team instructional strategies. For example, if upon analysis of the team tasks there are significant emergent requirements, then the instructional emphasis should be more on developing problem solving and decision making skills within the individual team members as opposed to training to rigidly structured responses to given situations.

The issue of team structure (serial vs. parallel) also is directly connected to the development of instructional strategies via the vehicle of

the team job/ task and training analysis. Once the task and its situational context is identified, a last requirement of the job/task and training analysis is to identify how the team is structured in the performance of the task. In team operations, there will seldom be a purely serial or parallel operation. The likely case for the team operation is that it is a combination of serial and parallel structured events. Therefore, the team job/task and training analysis should define at what points members are performing the same tasks simultaneously (parallel structure) and at what points the task performance is a stimulus-response type activity (serial). In turn, the instructional strategies for directing the student through the learning events will reflect the specific training task dimension by team structure as well as by situational context.

A CONCEPTUAL FRAMEWORK FOR COLT^2 INSTRUCTIONAL STRATEGIES

As stated earlier, the first interim report contained the results of a review of research literature related to the problem of developing instructional strategies for COLT^2. Additional bases for the report were interviews and personal contacts with instructors currently operating in the following team training environments: U.S. Army Field Artillery School (USAFAS), Ft. Sill, Oklahoma; Anti-Submarine Warfare (ASW) School, San Diego, California; Amphibious Base, San Diego, California; and Fleet Combat Direction Systems Training Center, San Diego, California.

The analysis of the data led to two major conclusions. The first was that a conceptual framework for a general purpose set of instructional strategies for team training does not exist. The second conclusion was that an ISD approach to team training has not evolved. The two conclusions are not mutually exclusive. A conceptual framework for team instructional strategies must in part rest on a team ISD approach for extracting the team training tasks, establishing student attributes and learner strategies, and identifying delivery system capabilities and matching them with tasks and students.

Thus, a primary thrust of the Task 1 study was to define instructional strategies within a conceptual framework which was responsive to elements developed during a team ISD process. Specifically, the report addressed the derivation of instructional strategies for COLT^2 by three elements: team training task dimensions, individual learner characteristics and strategies, and CAI system capabilities. The remainder of this section contains a discussion of instructional strategies based on the Task 1 findings. The focus of the discussion is on the three major elements comprising a team instructional strategy and what prior research findings are applicable to team training questions.

Instructional Strategies

The phrase instructional strategies was first described in 1961 by Stolurow as the logical flow of the instruction with consideration for branching structures for correcting error responses or applying remediation. The concept of instructional strategies thus has been with us for more than fifteen years. More recently it has been subsumed as an integral component by the systems approach to curriculum design and development. However, as pointed out by Gropper (1974), while the literature on instructional design has grown rapidly over the last several years, the formulation of instructional strategies has received little systematic description in most ISD models. Definitions of what is meant by instructional strategies are not usually comprehensive or operational. Gropper uses the term instructional strategies to refer to prescriptive rules for designing instructional events which create learning experiences appropriate for the mastery of behavioral objectives. According to this definition, the emphasis must be placed on the properties of behavior to which the instructional events must be responsive and then on the properties of the instructional events which make them responsive.

The documentation for interservice ISD procedures does not specifically use the phrase instructional strategies. However, the ISD components which are defined do contain the same elements of instructional strategies as defined by Gropper. After job/task analysis, selection of instructional setting, definition of objectives, and test development, the instructional sequence and structure is determined with specified learning events and activities. Thus, as with Gropper's definition, the strategies for meeting the required objectives consist of activities for sequencing, structuring, and specifying learning events/activities. More specifically, instructional

strategies, as defined by Hansen (1970), are the product of a series of decisions which provide for structuring the instruction by such variables as media choice, content, pacing, level of difficulty, reading level, or feedback.

In developing the conceptual framework for deriving team training strategies, it was concluded that these decisions are based upon three types of information: the characteristics of (1) the task to be learned; (2) the learner; and (3) the delivery system for instruction. In other words, $COLT^2$ instructional strategies are derived on the basis of task dimensions, learner characteristics/strategies, and CAI capabilities.

Team Task Dimensions

A number of team task dimensions were identified in the literature and through the personal contacts. From these dimensions, three categories of team learning were developed to serve as a link between team job/task analysis, team training objectives, and team instructional strategies. Descriptions of these categories are contained in the following paragraphs.

Knowledge of Team Roles. Central to a team effort is the understanding by each team member of the roles--authority, responsibility, and duties--of other team members. Moreover, knowledge of team roles includes being able to assess the capacity of oneself and other team members to fulfill the prescribed roles. Two skills, self-evaluation and team awareness, were identified within this category.

Self-evaluative skills are important in team training because an effective team member must learn to determine when an overload point has been reached and assistance is required from another team member (Boguslaw and Porter, 1962). This skill requires the analysis of one's own errors as well as knowledge of other members' loads such that determination of reduction of

load by another member can occur. Self-evaluation is related to the definitions of well-defined, assigned team roles and team goals because evaluation cannot occur without these criteria.

Team awareness (Kanarick, Alden and Daniels, 1972) centers on the knowledge of a team member about the roles of each team individual in relationship to the need for effective communication and interaction. That is, team awareness, as a task dimension, is related to the criteria of assigned roles which are formal and structured.

Team Attitudes. The terms confidence, aggressiveness, and pride were not addressed in the research literature. However, these attitudes and their manifestation in team-related behavior were emphasized by the team trainers who were interviewed. The instructors indicated that a team member must learn confidence in his abilities as an individual and then learn aggressiveness in his coordination as a team member. The dimension of pride also entered into these discussions. Statements from instructors indicated that teams must be trained toward specific team goals or a mission, and pride is a critical dimension to be addressed in the training. Most importantly, team pride must be related to the achievement of a team goal.

Team Communication. While communication is discussed as a coordination task for teams, generally the research and theory does not immediately allow for derivation of team communication definitions or strategies for teaching. However, two studies demonstrate that communication is an important part of a coordination task and training of such coordination skills develops more effective performance in a team. Johnston (1966), studying two person teams in a simulated radar situation, compared coordination skill training to individual training with a criterion task requiring communication. The findings indicate that performance was more effective when the coordination

skill training was given. In another condition, verbal communication was not required and, as might be expected, the coordination training was not effective in final performance.

Williges (1966) found that when two channels of communication, verbal and visual, were allowed, the verbal communication training had no effect on team performance. Federman and Siegel (1965) found that the transmission quality of the primary sensing data had a deciding influence on team performance for both communications and decisions. These two studies indicated that the team job/task analysis should have some focus on determining communication channels and the quality of the channels.

A study which provides some clues to types of team communication, especially as applied to coordinated tasks, was performed by Federman and Siegel (1965). This study investigated the relationship between antisubmarine warfare helicopter team performance and the content and flow of communications within the team during an attack. Fourteen different communication variables were found to be correlated with an objective performance measurement criterion (miss distance). A factor analysis of the fourteen communication variables resulted in four factors being identified: (1) probabilistic structure, (2) evaluative interchange, (3) hypothesis formulation, and (4) leadership control.

The factors defined by these fourteen variables demonstrate the close relationship between communications and decision processing. As defined by the authors of the study,

> Probabilistic structure is marked by situations in which extrapolations contain the thought processes involved in weighing alternatives, and in questioning and searching for answers to questions. Evaluative interchange is contained in communications in which there are direct requests for information and opinion, as well as the responses to these requests. Hypothesis formulation categorizes those communications involving interpretations of past performance in the

> mission and evaluation of future tactics to be followed. Leadership control describes communication marked by a role-assuming attitude; it serves to define goals and set assumptions for decision making.

While the study does not directly address training for these types of communication-oriented coordination tasks, the results suggested that the four correlated communications variables are team task dimensions which should be identified by a job/task analysis.

Summary. The review of the literature described in the first interim report provided a framework for analyzing TACFIRE team tasks and for deriving team training objectives from the job/task analysis. This framework is comprised of the three learning categories and their specific task dimensions as shown in Table 1.

Table 1. Team Learning Categories and Task Dimensons.

Learning Category	Task Dimension
(1) Knowledge of Team Roles	a. Self-Evaluation
	b. Team Awareness
(2) Team Attitudes	a. Confidence
	b. Pride
	c. Aggressiveness
(3) Team Communication	a. Probabilistic Structure
	b. Evaluative Interchange
	c. Hypothesis Formulation
	d. Leadership Control

Individual Learner Characteristics

For the purpose of illustrating the relevance of student characteristics to $COLT^2$, emphasis will be given to characteristics which may impact on the ability of the student to process information, communicate, make decisions and solve problems in a coordinated task environment. In this way a model of the learner will be tied to a model of the subject matter and allow derivation of $COLT^2$ strategies.

Learner characteristics may be used as a basis for a $COLT^2$ strategy with preprogrammed decisions or for teaching the learner strategies to use during $COLT^2$. To some extent, consideration of state characteristics, such as the score on the last test or the current state of anxiety, departs from the concept of entry behavior description because the measures may be used as dynamic indicators of a learner state. However, the discussion, to be relevant to $COLT^2$, must allow both for analysis of learner characteristics which will be used in designing instructional strategies and those which will be used during the instructional manipulation in a real-time, dynamic, interactive mode.

Dansereau, Actkinson, Long and McDonald, (1974), identified the following factors which potentially affect a learner's choice of strategies. Many of the same characteristics have been used in CAI strategies for selecting content, sequencing, and pacing. These factors are intellectual aptitude and the availability of strategy skills, personality variables, cognitive style, reception preferences, motivation, sex, and prior knowledge. The research on each of these factors is too extensive and diverse for even a brief summarization to be included in this document, but examples of some salient findings will be discussed. The purpose in discussing these examples of learner characteristics is to demonstrate how the general literature may be used to generate hypotheses concerning learner characteristics and $COLT^2$ strategies within the conceptual framework presented here. The hypotheses will have to be answered empirically.

<u>Intellectual Aptitude and Availability of Strategy Skills</u>. Several examples that relate the learner characteristic of intellectual skills to the categories of team learning discussed earlier are provided. Conceptual complexity, the capacity to integrate and interrelate dimensional units of

information, is an intellectual aptitude that can be measured (Schroder, Driver and Steufert, 1967) and that appears to be an important factor in determining the types of learner strategies upon which an individual can call. The characteristic might be considered for training team members to integrate information about team member roles in relation to the team goal. Research suggests that conceptual complexity can be manipulated through training (Sieber and Lanzetta, 1966).

Dansereau, et al. (1974) employed the Structure of the Intellect Model (Guilford and Hoepfner, 1971) as a framework for discussing the availability of learner strategy skills. In the model, the following five intellectual operations have been identified by factor analysis of a large variety of paper and pencil tasks:

(1) Cognition - Immediate discovery, awareness, rediscovery, or recognition of information in its various forms, comprehension or understanding.

(2) Memory - Fixation and retrieval of information in storage.

(3) Divergent Production - Generation of logical alternatives from given information, where emphasis is upon variety and quantity.

(4) Convergent Production - Generation of logical conclusion from given information, where emphasis is upon achieving unique or conversationally best outcomes.

(5) Evaluation - Comparisons of items of information in terms of variables and making judgments concerning criterion satisfaction.

Research indicates that the ability to perform these operations strongly relates to achievement (Guilford, Hoepfner and Petersen, 1965; Dunham, Guilford and Hoepfner, 1968; Caldwell, Schroder, Michael and Meyers, 1970). The structure of intellect operations may correspond to the basic skill components required for the development and implementation of learner strategies. For

this reason, the intellectual operations correspond with the categories of learner strategies developed in a subsequent section of this report. These characteristics offer face validity as relevant to a team member's ability to process the information communications in either a man-man or man-computer-man situation.

Personality Variables. Three examples are provided to illustrate the influence personality variables may have on team performance. Dogmatism and tolerance of ambiguity primarily influence strategy selection in tasks involving the manipulation of ambiguous or belief discrepant information (Rokeach, 1960; Feather, 1964). The characteristics could be useful for communication training involving risk willingness or reluctance as defined by Federman and Siegel (1965) and discussed earlier in the section on team dimensions.

A measure of the personality construct, locus of control, was developed by Rotter (1966). The construct itself is viewed as a generalized expectancy about control over the environment with a wide variety of situations included within the spectrum of generalization. Internal control refers to the individual's belief that an event is contingent on his/her own behavior or characteristics. On the other hand, an individual characterized by external control attributes the occurrence of a significant event to fate, luck, or to the control of others or as being unpredictable (Rotter, 1966). Judd, O'Neil and Spelt (1974) conducted an extensive review of the research that has appeared since Rotter's initial formulation. The research indicates that the external subject requires more specific guidelines than the internal subject in order to perceive his own needs and take the opportunity to control. It also appears that increasingly well-defined task instructions provide a missing cognitive link for external subjects which helps them to

improve their performance. The locus of control characteristic may assist, therefore, in defining instructional strategies for adapting the feedback and prompting to team members during COLT^2 communications--especially those associated with decision processing.

Cognitive Styles. Dansereau, et al., (1974) discuss cognitive style as a characteristic which creates boundaries on the types of learner strategies available to individuals. Cognitive styles are considered to be preferences in perceptual organizing and conceptual categorizing of the environment. A number of specific cognitive styles have been identified. While we will not attempt to go into the specific investigations of the relationship between cognitive style variables and performance, it should be noted that there are indications that cognitive styles are a variable to be considered in the development of adaptive instructional methods which match media or level of difficulty to the learner's style. The applicability of cognitive style characteristics to COLT^2 is presented with one example.

Cognitive style tests, named field dependence/field independence (Witkin, Lewis, Hertzman, Machover, Meissner and Wapner, 1954), measure the ability to isolate and process simple information from a more complex informational environment. The tests use geometric figures but seem to have correlation with a variety of real tasks. Kennedy (1972) found field dependence to be related to success in aviation training. The characteristic may have applicability to the communication training required for interaction between the artillery control console operator and fire direction officer in TACFIRE. Each has a separate display of complex information and each must isolate information from it. The operator must isolate and pass information to the officer and the officer must make a decision based on that information and his own and then pass back an order to the operator.

Reception Preferences. Research has indicated that individuals have preferences for receiving information in certain ways (Hartnett, 1973). As with cognitive styles, these preferences can influence the strategies available to a student and the effectiveness of the application of an instructional strategy. Reception preference characteristics may be related to communication training. For example, Willeges (1966) found that when two channels of communication, verbal and visual, were used in a team, verbal communication training had no effect. Reception preference may be the reason for students using only the visual channel and not the verbal channel available to them.

Motivation, Sex, and Prior Knowledge. It should also be noted that there are a number of other individual difference variables that could potentially influence the selection and utilization of particular learner strategies during COLT^2. Any comprehensive attempt to identify these variables and to take them into account for COLT^2 instructional strategies would have to include the motivation, sex and prior knowledge of the subjects involved in the instruction. Each of these variables has proven to be significantly related to learning outcomes.

Summary. The above subsections provide examples of student entry characteristics which may impact on the design and manipulation of learning events. The categories of learner characteristics include (1) intellectual aptitude and availability of strategy skills; (2) personality variables; (3) cognitive styles; (4) reception preferences; and (5) motivation, sex, and prior knowledge. The research behind the variables presented indicates that frequently significant differences in performance and achievement are attributable to the individual's composite of values related to these variables.

Learner characteristics, in turn, may serve in part as the basis for instructional design--addressing such issue as content, sequencing, pacing,

levels of difficulty, or instruction medium. Within COLT^2 instructional strategies, learner characteristics also may serve as the basis for the real-time, dynamic manipulation of both student and learning events.

Individual Learner Strategies

The three categories of learner strategies discussed in this section were first developed by DiVesta (1971) and maintained by Dansereau et al., (1974) in a report for the U.S. Air Force. The categories are made up of comprehension, memory, and problem solving strategies. The remainder of this section will deal with each of these learner strategy categories--attempting to define the parameters of each category and providing a brief summarization of the state-of-the-art for learner strategies included within each category. A series of tables corresponding to the learner strategy categories is included in the first interim report for this project. Each table includes specific strategies, a summary of the research with implications for instruction, and a list of references. The purpose of the tables is to illustrate the current directions of individual learner strategy research.

Comprehension Strategies. Comprehension strategies relate to the acquisition of cognitive processes that occur during learning. Specifically, the strategies which have received the preponderance of attention from researchers are those which attempt to explain how the learner understands. As reviewed by Dansereau, considerable research has been conducted for the purpose of ascertaining the facilitative effects of comprehension strategies in the instructional process. The discussion on comprehension strategies includes coverage of the effects of organizational strategies (advanced organizers, passage organization, and post organizers), the effect of questions, notetaking, rule presentation, presentation of learning objectives, and reading flexibility.

Generally, the research dealing with comprehension strategies has progressed beyond the "basic" stage and specific implications for educational applications can either be inferred or posited on the basis of empirical findings. Many of the comprehension factors which appear to have a substantial impact on student performance also have implications for the development of educational materials. Furthermore, the dimensions of comprehension strategies for individuals appear to hold for team training.

Comprehension strategies are closely associated with team awareness. For example, a number of researchers have demonstrated that students tend to organize external stimuli in consistent, systematic patterns (Dansereau, et al., 1974; Cofer, 1966). In turn, the preorganization of instructional materials to correspond with those patterns has led to more efficient learning since the student is not as dependent on rational processes. In team awareness training, the organizational structuring of the materials in terms of content, sequencing, and display may be critical if the desired learning is to occur.

Memory Strategies. Atkinson and Shiffrin (1968) have argued for the importance of strategies in determining which information is entered into and retrieved from short- and long-term storage. These authors refer to processes that are not permanent features of memory, but rather transient phenomena under the control of the subject, as control processes. The appearance of these processes depends on such factors as the instructional set, the experimental task, and the past history of the subject. The purpose of this section is to discuss specific examples of these control processes as memory strategies, and if possible, to extend them into the instructional domain.

Memory strategies include the presentation of selection cues, mnemonic techniques, visual imagery, subjective organization, memory management, and retrieval. Of the learner strategies listed, the first three appear to have direct and positive implications for instructional settings. Subjective organization, memory management, and retrieval strategies, on the other hand, have not proven, as yet, to constitute viable operational strategies for the development of instructional materials or for the specification of *instructional strategies.*

Selection cues and the use of mnemonic techniques have always been an integral part of Army artillery verbal communications. The TACFIRE system, when in a digital mode, converts the traditional verbal messages into visual representations displayed on the TACFIRE CRT. Selection cues are reflected in the message format but no research has been conducted to establish the effectiveness of the present techniques.

Problem Solving Strategies. The third category includes learner strategies associated with problem solving techniques. This category can be further broken down into learner strategies associated with problems which fall into two major types: closed-system problems and open-system problems. Bartlett (1958) described closed-system problems as ones that are formed in such a way that all the elements for solution are available and the problem solver has to fill in the appropriate element. In essence, closed-system problems are characterized by the existence of an identifiable solution and further, progress toward this solution is usually also identifiable. Examples of closed-system problems would include anagrams, chess, logic, math problems, concept formation, equipment repair (troubleshooting), navigational problems, etc.

In open-system problems the problem solver must go beyond the units immediately given in order to discover a solution. Neither the solutions nor the progress towards solutions are readily identifiable. Examples of open-system problems include determining unusual uses for common objects, creating cartoon captions and movie titles, inventing a new device or product, writing a term paper, etc.

In closed-system problem solving three distinct approaches have been investigated: (1) partist strategies; (2) wholist strategies; and (3) heuristics. Although only limited research has been conducted on each of these closed-system problem solving strategies, and research findings on the subject are not particularly substantial, there are implications for instructional processes associated with each strategy.

A good example of how problem solving is related to team instructional strategies is a "brainstorming" session. Members of a "brainstorming" group confront open-system problems on a team basis--each individual contributing ideas yet building, whole or in part, on the contributions of the other members. A Delphi exercise is another example of team open-system problem solving.

To illustrate team closed-system problem solving, an excellent example can be taken from Army artillery procedures. The most important problem faced by artillery personnel is how to accurately and effectively fire a round at an enemy. In order to resolve the problem, a number of individuals must coordinate information and actions.

<u>Summary</u>. Individual learner strategy categories are made up of comprehension, memory, and problem solving strategies. Comprehension strategies relate to the cognitive processes underlying individual learning. Included are instructional organization, the effect of questions, notetaking,

rule presentation, presentation of learning objectives, and reading flexibility. Memory strategies relate to the entry and retrieval of information from short- and long-term storage. Memory strategies include the presentation of selection cues, mnemonic techniques, visual imagery, subjective organization, memory management, and retrieval. Finally, learner strategies associated with problem solving techniques are placed in a third category. These strategies may further be grouped as they relate to either closed- or open-system problems.

The analysis of the literature that is related to learner strategies indicates that a number of strategies have proven effective in the design of instructional materials. Foremost among these are material organization and student interaction (comprehension strategies); the use of selection cues, mnemonics, and visual imagery (memory strategies); and training of deductive and heuristic techniques (problem solving strategies). Moreover, in most instances the strategies would appear to hold for team training environments as well as for the individual environments in which they have been investigated.

Computer-Assisted Instruction Capabilities

CAI is a set of programmed components for presenting information, providing student interaction, monitoring student progress, and manipulating the sequence of instruction. Instructional strategies encompassing CAI as the delivery system are distinct only in that they reflect the functional capabilities of the hardware and software unique to CAI systems. The prime purpose of this subsection is to briefly describe the implications for $COLT^2$ instructional strategies of CAI systems hardware and software and to discuss how current CAI operational modes are tied to $COLT^2$.

Hardware and Software Capabilities. A prime component of media hardware for CAI is the presentation device. Several different types of visual

information may be presented depending on the system. In some systems only alphanumeric text can be displayed, and in others, it is possible to represent pictorials by graphics. The type and complexity of graphics may also vary. For example, still graphics such as diagrams, graphics which have partial movement only, or full dynamic graphics similar to animation may each be possible depending on the system. Some systems also have the capability to present slide or microfiche pictures. Other systems are capable of presenting motion pictures through computer-controlled videotape, as exemplified by TICCIT developed by the MITRE Corporation or the Navy Personnel Research and Development Center's Computer Controlled Multi-Media System $(CM)^2S$. The use of split screens or more than one visual presentation monitor is also possible, such as the Computer-Based Training System developed by General Electric Ordnance Systems or the $(CM)^2S$ system. As an example of how the presentation media relates to $COLT^2$ strategies, one review of team training (Wagner, et al., 1976) suggested the possibility of using split screens to present information relevant to the position being trained, as well as information showing the trainee the status of the coordinating position.

Response devices, as part of the media hardware, also influence which instructional strategies are possible. Typical response devices include standard keyboards, special function keyboards, graphic writing tablets, lightpens, touch panels, voice recognition systems, a device similar to a track ball called a mouse, and special adjunct console controls. The choice of response device determines the mode of input during the interaction of student and system.

Because of the nature of the presentation and response devices in a general purpose CAI system, questions of fidelity and transfer of learning for many tasks involving equipment operator training may arise. It should

be recognized that CAI instructional strategies, such as student progress diagnosis in real-time, pacing, adaptive instruction, feedback, and optimization, can be included in many real man-machine systems with greater fidelity available than on general CAI systems.

Similarly, the computer software available influences instructional strategies. Just as the current team training version of PLANIT can assist in developing $COLT^2$ instructional strategies, we may expect additional software capabilities to provide for other strategies. Software capabilities required can also be related to computational capabilities, such as those used in optimization or adaptive techniques, and control of media hardware presentation and response devices.

CAI Modes. Table 2 presents the names of instructional strategies found in the literature on CAI. It should be noted that several of these names are repeated in the various categorizations of instructional strategies. For example, drill and practice and a tutorial CAI are represented in some way in most of the lists. Only Hickey's (1968) definitions are shown since he has summarized most of the others.

However, while these names are termed instructional strategies, as in the case of Hickey, they are probably more properly called modes of CAI in that they represent purposes for which CAI may be used in the overall instructional design. For example, drill and practice may be used, as described by Suppes (1969), to supplement the regular curriculum taught by a teacher. The introduction of concepts and new instruction is handled in a conventional fashion by the teacher, but the computer takes the role of providing review and practice on those concepts and new instruction. While drill and practice represents an instructional strategy in part, there are many more details to consider. For example, in the Stanford program on mathematics (Suppes, Jerman

Table 2. Representative CAI Modes

Hickey (1968)

(1) Tutorial
  (a) Linear: straight line, non-individualized instruction
  (b) Intrinsic: individualized, branching instruction
  (c) Adaptive: instruction which uses decision-making models to make successive decisions from instructional alternatives to adapt the instruction to the learner

(2) Socratic: Tutorial but allowing student to assert an answer or solution and ask for information. Similar to Suppes Dialogue mode.

(3) Learner Controlled: Instruction allowing student to select path of events.

(4) Simulation: Instruction which duplicates in the learning situation the format and sequence of stimulus events in the real world.

(5) Game: A form of simulation involving situations of competition or conflict.

(6) Testing: Testing is viewed as an instructional strategy by Hickey because, with CAI, techniques may be used encompassing branching, math models, decision theory, and other decision-making procedures of CAI. The testing may also be embedded in the CAI as an integral part.

Suppes (1969)
(1) Drill-and-Practice
(2) Tutorial
(3) Dialogue

Stolurow (1969)
(1) Problem Solving
(2) Drill-and-Practice
(3) Inquiry
(4) Simulation and Gaming
(5) Tutorial Instruction

Zinn (1967)
(1) Drill
(2) Author Controlled Tutorial
(3) Dialogue Tutorial
(4) Simulating and Gaming
(5) Retrieval and Reorganization of Information
(6) Problem Solving
(7) Artistic Design
(8) Composition

Rodgers (1967)
(1) Drill
(2) Tutorial
(3) Conversational
(4) Simulated Environment
(5) Simulated Decision

and Brian, 1968), an algorithm was developed for determining mastery of materials and adapting the drill to a learner's state. Algorithms of this sort can vary and, as they vary, represent differences in the instructional strategies. *In fact, it is one of* the benefits of CAI that such algorithms can be performed in real-time with dynamic decision making about the student's learning state and the information to be presented.

The point is that the instructional strategies represented in Table 2 are actually overall purposes which are probably better termed modes. Instructional strategies per se are more appropriately considered to be combinations of the CAI modes, the media characteristics, the algorithms used as a function of the software available, the components of the instructional setting which are adjunct to the computing system, and other factors.

Finally, while the modes of CAI described above denote the general characterization of instructional strategies in a computer-based system, they do not specifically delineate the techniques used to achieve the goals (direct instruction, drill, etc.). The decisions in specifying COLT^2 instructional strategies are many and include content, amount and type of student control, media selection for presentation and interaction, difficulty levels, adjunct materials, and pacing. In short, the decisions are based on information from each of the conceptual framework categories that have been established. The distinct advantage of COLT^2 over other instructional media forms is CAI can incorporate measurement and computational techniques that can more fully integrate these dimensions and allow for more individually oriented strategies.

The measurement techniques used in CAI *are in fact* part of the instructional *strategies* since many of the presentation variables, response modes, and sequencing techniques, as well as student evaluation, depend heavily on the

measuring techniques used (Hansen and Johnson, 1971). In adaptive instruction, for example, preliminary measures such as scores on personality scales, achievement scales, and aptitude scales may be used in regression models (Rivers, 1972; Suppes, Fletcher and Zanotti, 1973a, 1973b). These student characteristics, including measures of learner strategies, are also the basis for many of the decisions in CAI instructional strategies, both pre-instruction and within instruction. Besides these measures, within instruction measures are usually in two forms: (1) the criterion examination, and (2) response latencies. Another type of measure sometimes used is error rate. Several items of importance for measurement strategies in $COLT^2$ may be noted at this point. First, as pointed out by Faust (1976), very little has been done in measuring team learning progress within instruction. Usually only a final criterion measure is used to measure team effectiveness. Along these lines also, little has been done to measure specific team task dimensions other than communications variables. Secondly, measures of team performance do not usually have well-defined conditions for the role and specific behavior of each individual in relation to the team goal.

Summary. The primary CAI capabilities which impact on $COLT^2$ instructional strategies may be grouped into hardware and software categories. Hardware capabilities essentially reflect presentation and response devices. In turn, the characteristics of both devices are delimiters of the interaction between students and system. Software capabilities underlie the CAI modes available to a lesson author and, thus, also are a factor to be accounted for in the instructional strategy. Examples of CAI modes include drill, tutorial, learner controlled, simulation, game, and testing. Further, $COLT^2$ instructional strategies are based in part on the capability of the language system to provide coordinating functions among team members.

A third consideration in COLT^2 instructional strategies is the measurement technique employed in the CAI. Many of the presentation variables, response modes, lesson sequencing, and student manipulation depend heavily on what information in regard to student characteristics and performance and what capability exists to analyze the data. These measures are the basis for many COLT^2 instructional strategy decisions, both pre and within instruction.

Implications for Developing Team Instructional Strategies

As defined by Hansen (1970), an instructional strategy is a series of decision points which lead to the sequencing, structuring and specifying of learning events and activities. Variables such as media choice, content, pacing, level of difficulty, and feedback are examples of outputs from the decision making. Information underlying these decisions is based on the characteristics of (1) the task to be learned, (2) the learner, and (3) the instructional delivery system. In turn, team instructional strategies must account for the variables representing each of these dimensions within a context typically requiring multiperson interactions. The coordinating and cooperative behavior present in the job must also be present in the training.

The first step in developing team instructional strategies is to identify the team tasks. Team tasks are defined by the task dimensions previously discussed and their parameters set by the task situation (established to emergent) and by the intra-team member structure (serial or parallel) typically established for achieving the task. A clear delineation of tasks by content, situation, and team structure is critical to developing effective team instructional strategies.

Specifically, the team instructional strategy must represent the job/tasks by the team requirements which go beyond the individual technical proficiency

requirements. For example, team operations are enhanced by a thorough understanding by each team member of the roles--authority, responsibility, and duties--of other team members and how one's own role couples with the roles of other team members. Knowledge of team roles is important when the team functions in serial and in parallel and in both established and emergent situations. Further, effective teams are frequently characterized by compensatory behavior; that is, one or more team members perform tasks which are not typically defined as their responsibility. The bases for compensatory behavior are numerous (e.g., individual weakness, situational task overload, equipment outages, etc.). What is critical is that team members recognize potential catastrophic situations, make correct judgments as to how they can contribute to the correcting of a team "malfunction," and take corrective actions. Each of these steps is dependent on team members having the skills to evaluate their own as well as other team members' performance.

Other facets of knowledge of team roles include error recognition and analysis, formulation of intra-team feedback, and reception and evaluation of feedback messages. Individual technical proficiency underlies each of these facets. However, team training focuses on teaching the individual how to optimally apply his skills and knowledge within a dynamic team environment. In addition to knowledge of team roles, team attitudes and team communication are task dimensions which must be addressed by team instructional strategies.

Second, decisions regarding the structuring and sequencing of learning events must incorporate attributes, aptitudes, and strategies related to the individual learners who will comprise the operational team. Prior research on learner characteristics and strategies has primarily dealt with the individual learner working on single person tasks. Thus, as a general statement, it can be said that further investigation should center on the

relationships among such variables as team personality complexion, cognitive styles, reception preferences, motivation, sex, and prior knowledge as factors which effect team information processing, communications, decision making, problem solving and task achievement. The desired outcome of a program of research would be a model of team composites and learner strategies which could be matched with specific team training task requirements.

In the interest of the present project and current team training efforts, those learner characteristics and strategies which appear to hold for team training are important. Among these are selected comprehension, memory, problem-solving and feedback strategies. The applicability of each to team training has been discussed in prior subsections. It seems appropriate, however, to provide a synopsis.

Comprehension strategies are based on the cognitive processes which occur during learning. They are manifested in training through the organization of instructional materials, student interactions, and the types and level of materials presented to the student (i.e., objectives, rules, reading flexibility, etc.).

There is no reason to believe that comprehension strategies are less important to team training than to individual training. On the contrary, they may be more critical. For example, student interaction strategies are primarily concerned with the interface of student and material (e.g., effect of questions, notetaking, instructional prescriptions). In team training the student/student interface, as representative of team member interaction, is an added critical dimension.

Memory strategies relate to the entry and retrieval of information from short and long term memory storage. Specific strategies related to this process include the presentation of selection cues, mnemonic techniques,

visual imagery, subjective organization, memory management and retrieval. As stated previously, the first three strategies have the greatest immediate implications for training and the development of team instructional strategies.

In the development of the brassboard materials, selection cues were used extensively. The cues were based on the priority and importance of the information presented in terms of task achievement. In addition, a form of mnemonics was employed to represent team communications. Finally, visual imagery was stimulated. The project team considered this strategy to be critical to retention of the materials (rules) to be learned and to the enhancement of learner attitudes and motivation.

Selected closed-system problem solving strategies are applicable to military team training problems and could effectively be represented in learning events. For example, TACFIRE operations at the Battalion Fire Direction Center require a dynamic interplay of partist and wholist problem solving techniques. Partist strategies, in the form of reception paradigms, are appropriate to the analysis of TACFIRE operational messages. In essence, the operator entertains positive instances and selectively scans the message data to test and enlarge on the instances. The hypothesis related to actual combat conditions is derived.

Wholist strategies also are integral to tactical problem solving. The Fire Direction Officer (FDO) is taught tactical hypotheses covering a broad range of combat situations (these hypotheses also are represented in the fire plan). As the battlefield scenario unfolds, the FDO constantly checks the positive instances (actual occurrences) with his hypotheses to determine his tactical decisions. Both partist and wholist strategies are represented in the training scenarios developed for the brassboard demonstration/evaluation.

Finally, feedback strategies are proven effective in individual training. The most difficult aspect of implementing comprehensive feedback strategies in team training is differentiating individual team members' contributions to the team effort. COLT^2 offers the optimum solution to this problem as each member can be monitored online simultaneously to the total team evaluation and feedback. A second major team feedback issue has not been addressed. That is, in most team operations there is a 'process' paradigm which yields most reliable results. Therefore, both process and product evaluation models need to be developed in order to more uniformly train to team activities. Such a process model would have the capacity for providing corrective feedback.

In summary, there are a number of learning strategies which currently should be considered as part of the data base from which team training is developed. Notably excepted from this group, however, are personality variables, many of which have served as good predictors of performance and as a basis for prescriptive instruction. There is little research in this area from which conclusions regarding optional make-up or complexion of teams can be drawn.

Finally, the third dimension of the conceptual framework for devleoping team instructional strategies encompasses the instructional delivery system or instructional medium. For the present study, the medium was CAI. The COLT^2 instructional strategies accounted for the hardware and software capabilities present in PLANIT and the operating system available. In short, instructional strategies are delimited by the medium through which the learning is to occur. A detailed description of the potential of the team training version of PLANIT is contained in the Discussion section.

DESIGN AND IMPLEMENTATION OF A TEAM ISD MODEL: BRASSBOARD DEVELOPMENT

Overview

In developing the CAI "Brassboard", a team ISD approach was designed and implemented. The major components of the approach included job/task analysis, development of team learning objectives, and scenario development inclusive of instructional strategies. In turn, each of the components was developed in a manner that reflected the team training concepts and issues that are discussed in the previous sections. For example, the job/task analysis accounts for team behaviors required for both an established and emergent TACFIRE environment as well as defining each task in terms of either a parallel or serial operation. Further, the instructional strategies underlying the scenarios are based on the team task dimensions, individual learner strategies, and PLANIT capabilities.

The following subsections discuss the ISD procedures involved in developing the brassboard and describe the materials developed.

Selection of TACFIRE Functional Area to be Analyzed

For the task of developing and demonstrating a set of systematic procedures for conducting a team job/task and training analysis, representative samples of TACFIRE operations were selected to be analyzed. The following criterion categories were established as the basis for the selection of a TACFIRE functional area:

(1) As directed in the statement of work, the job/task and training analysis must be conducted for two classes of team training (a) the man-computer-man paradigm, and (b) the man-(noncomputer)-man setting. In selecting an aspect of TACFIRE operations for analysis, these classifications of interaction had to be represented.

(2) The second category of selection criteria had as a basis that the functions to be analyzed must be representative of critical TACFIRE operations. Within this category the following criteria were posited: (a) the function is directly related to mission success; (b) the function is performed frequently; and (c) the function represents a specific block of activities, i.e., has a specific beginning, end, and logical continuity throughout.

The second category of criteria was also employed by ARI in the selection of primary functions for automated individual (AI) training. In that analysis of TACFIRE documentation, operation of the system, and discussions with TACFIRE personnel, ARI concluded that many of the functions performed at the Division Artillery Fire Direction Center (DivArty FDC) and the Battalion (Bn) FDC were similar. Subsequently, the Bn FDC sphere of operations was selected as the organizational context for developing AI training. The same sphere of operations has been identified as appropriate for the team job/task and training analysis. The Bn FDC sphere of operations fulfills the second class of selection criteria, and there are representations of both man-computer-man and man-man interactions.

The TACFIRE Bn FDC, is operated essentially by a three man team: the Fire Direction Officer (FDO), the Fire Direction Sergeant (FDS) and the Communication Control Unit Operator (CCUO). The major figures are the FDO and FDS. In the actual selection of a function area for the team job/task and training analysis, a major consideration was that the points of greatest interaction between the FDO and the FDS were represented. In fact, an almost complete overlap exists between the tasks of the FDO and the FDS in the Bn FDC. The responsibility for operations and decision making rests with the FDO, but TACFIRE operational knowledge and skills apply to both. These points

of interaction have been identified both within the TACFIRE documentation and previously performed job/task analysis.

In reviewing the TACFIRE documentation and the functional areas of responsibility of the Bn FDC, three primary points of interaction between the FDS and the FDO emerged. These three primary points fell within the Tactical and Technical Fire Control Functional area. The first point was conduct of a fire mission (FM)--processing fire missions, producing firing data, and recording and reporting fire missions. The second was maintaining and updating the data bases that permit tactical and technical fire direction to be accomplished. The third was system operating messages (SYS) used to initialize and update the Fire Control Computer files for operation within the FDC and within other subscribers.

For the purpose of the team job/task and training analysis the first of these general areas, conduct of a fire mission, was selected for analysis. The content and procedures in conducting a fire mission are a complete entity in themselves, as well as a culmination of the application of individual learning that has occurred in TACFIRE training. In addition, the conduct of fire missions represents a broad range in complexity for team training tasks. Specifically, the analysis focused on three job areas: (1) process FM in Automatic Mode, (2) process FM in Manual Mode, and (3) process FM received by Voice Communication.

Job/Task Analysis Procedures

The major questions asked in the team job/task and training analysis were: (1) what does a Bn FDC team look like when operating in an established situation? and (2) what changes in team interactive behaviors may occur in specific emergent situations? In order to answer these questions, as much

data on team activities and performance was obtained as possible. The data were based on an analysis of TACFIRE documentation prepared by the U.S. Army Field Artillery School (USAFAS), Ft. Sill, Oklahoma, dir ct observation of teams during a Command Post Exercise (CPX) at USAFAS, detailed interviews with TACFIRE personnel at USAFAS, and a survey of TACFIRE instructors.

A detailed team job/task and training analysis was made of the Bn FDC team functions. This analysis included a description of each act carried out by team members and the sequencing of the acts. Every act of team members was broken down into three elements: input, the signal or stimuli that elicits the behavior; process, the response; and output, the signals or stimuli resulting from the process. Each act was then linked to subsequent acts as either a man-man interaction or a man-machine-man interaction. In this way it was possible to set up a team task flow for the established situation. Figure 1 is a segment extracted from a team task flow chart.

The man-machine-man interaction is representative of two types of machines, the radio and the computer, and of two types of machine mediation. The first type of machine mediation requires only that the machine be a vehicle for transmitting data from one point to another. The radio always performs this type of function; the computer frequently does. The second type of machine mediation requires that the machine perform a function which before its introduction was performed by man or a different, and probably a less sophisticated, machine. The function may be, for example, a calculation, record keeping, a check of procedures, or even the making of a decision. Only the computer, with its associated peripherals, can perform these functions. Thus, in the job/task flow charts the types of system programs (e.g., TTFC and AFU) used for data analysis and manipulation by the computer are identified as well as if the machine mediation is solely for the data transmittal.

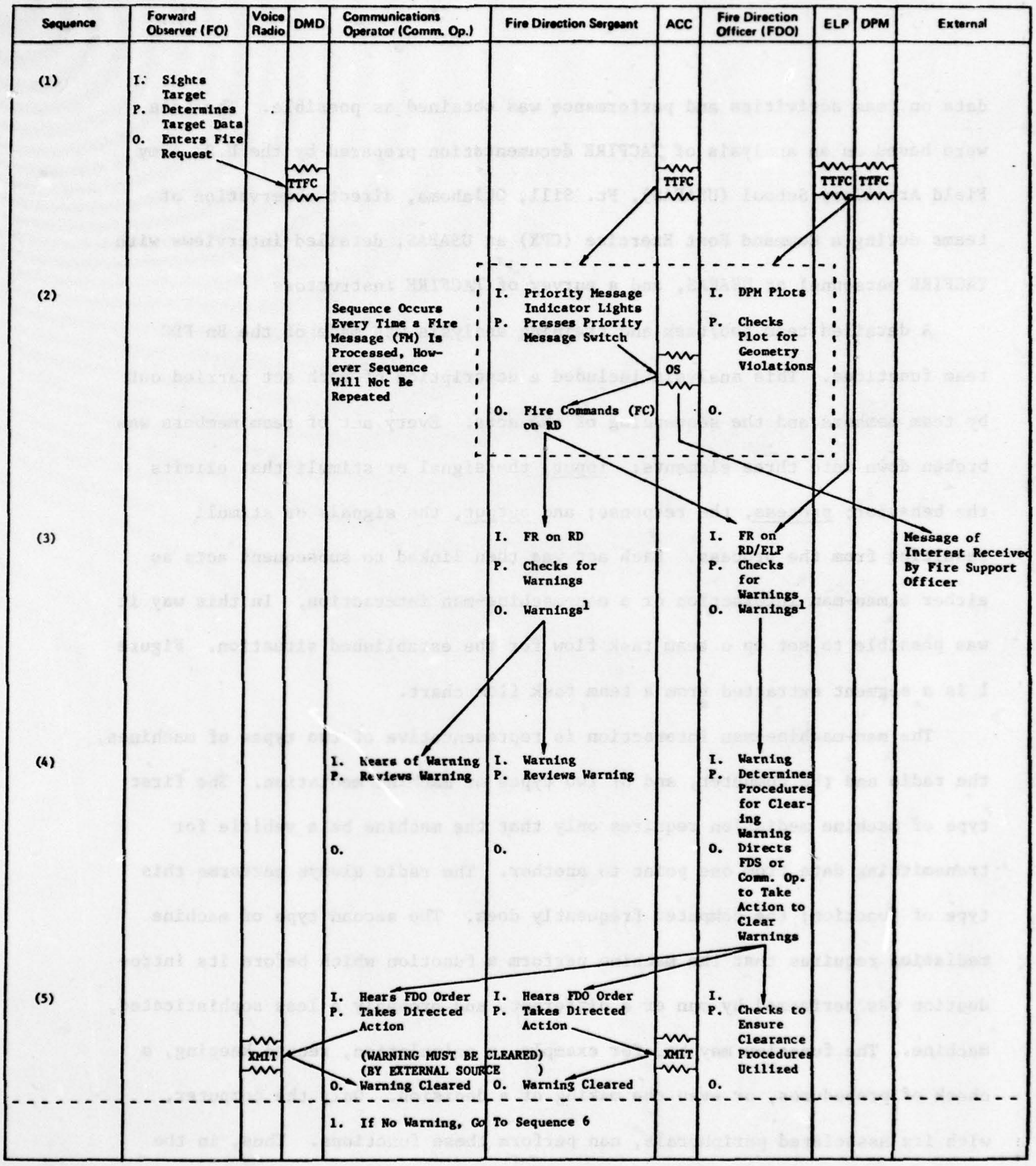

Figure 1. Excerpt from Job/Task Flow Chart of Fire Mission Processed in Automatic Mode.

After completing the job/task flow charts, a task/subtask summary table was developed for each mode of processing a fire mission (see Table 3). The task/ subtask summary tables represent major tasks and subtasks which comprise a fire mission. Thus, the table identifies what tasks are exercised in each mode of processing a fire mission and provides the following information:

(1) Team member involvement,

(2) Type of team structure (serial or parallel),

(3) Class of interface (man-man or man-machine-man), and

(4) Task (training) dimensions.

The last category includes the task dimensions making up the learning categories discussed previously. Two dimensions had to be reclassified. Probabilistic structure as a communication dimension was changed to information prompting. This dimension included messages which cue other team members that their attention and action are required. Second, the communication dimension of evaluative interchange was called *information interchange* and denoted the reception and transmission of messages containing mission related information. An example of the former would be the message 'Fire Mission' - alerting all team members to be ready. An example of the latter would be a message from the FDS to the FDO stating that "Charlie battery has just run out of ammunition." The other communication dimensions remain the same.

In turn, emergent situations were identified at each point of team member interaction and possible reactions to contingencies were specified. The range of possible solutions to contingent problems served as the basis for developing emergent team training objectives as well as identifying critical training nodes.

Table 3. Example Summary Table of Team Characteristics for a Fire Mission Processed in the Automatic Mode.

Task/Subtask	Member Involvement: FDO	Member Involvement: FDS	Member Involvement: COMM OP.	Team Structure: Serial	Team Structure: Parallel	Class of Interface: Man-Man	Class of Interface: Man-Machine-Man	Task Dimension: Self-Evaluation	Task Dimension: Team Awareness	Task Dimension: Confidence	Task Dimension: Agressive-ness	Task Dimension: Pride	Task Dimension: Info Prompting	Task Dimension: Info Interchange	Task Dimension: Hypothesis Formulation	Task Dimension: Leadership Control
1.0 Process Initial Fire Request																
1.1 Receive Fire Request From FO																
1.2 Prepare FM:RFAF Message																
1.3 Take Computer Action																
2.0 Process FR Message (RFAF,SUBS,FFE) With Fire Commands																
2.1 Receive FM Message	x	x			x		x	x	x	x	x	x	x			
2.2 Review FM Message	x	x			x	x		x	x	x	x	x		x	x	x
2.3 Transmit Fire Commands	x	x			x		x	x	x	x	x	x				x
3.0 Process Warning Messages																
3.1 Recognize Warning	x	x			x	x		x	x	x	x	x	x			
3.2 Determine Action to Clear Warning	x	x		x		x		x	x	x	x	x		x	x	x
3.3 Take Action to Clear Warning	x	x	x		x		x	x	x	x	x	x				x
4.0 Process Messages to Observer																
4.1 Determine Content of Message																
4.2 Transmit Message to Observer																
5.0 Process EOM and MFR																
5.1 Receive EOM Data																
5.2 Prepare EOM Message																
5.3 Take Computer Action																
5.4 Display MFR		x		x	x	x		x	x	x	x	x	x			
5.5 Review MFR	x	x		x	x	x		x	x	x	x	x		x	x	x
5.6 Take Computer Action	x	x				x		x	x	x	x	x				x
6.0 Process Message Corrections																
6.1 Review Message/Recognize Error	x	x			x	x		x	x	x	x	x		x	x	
6.2 Determine Action	x	x		x	x	x		x	x	x	x	x		x	x	x
6.3 Take Action	x	x			x		x	x	x	x	x	x				x

Development of Team Training Objectives

The team training objectives were organized by task and subtask. Criterion objectives reflect the condition and behaviors underlying the team achievement of a task. Enabling objectives reflect the necessary subtask behaviors of team members which, collectively, result in the accomplishment of the task.

In deriving the enabling objectives, each subtask was examined in terms of the team task dimensions. If the presence of a team task dimension within a given subtask element was established, then an enabling objective was developed to represent that dimension. Thus, each subtask element was reviewed within the learning category/task dimension framework constructed during Task 1. Table 4 presents a sample of team training objectives.

Scenario Development

The major objective in creating the $COLT^2$ scenarios was to develop a team training vehicle rather than simply a multiperson drill and practice sequence. As a training vehicle, the scenario had to be capable of incorporating instructional strategies reflecting the tasks and tactical situations, addressing individual learner requirements, and providing for the computer management of all facets of the instruction including student responses. Thus, the scenarios had to be structured to ensure flexibility at the decision points for manipulating training resources in order to maximize performance and minimize training time. With this objective stated, two basic assumptions were made:

1. Team training scenarios are task and environment specific in nature. For weapon system training, the scenario must represent team member roles, information flow, decision points, problem solving requirements, coordination activities, operational doctrine, and tactical evolutions.

Table 4. Example of Fire Mission Team Objectives.

TEAM TASK DIMENSION	CRITERION OBJECTIVES	ENABLING OBJECTIVES
Confidence	Team members of the Bn FDC will indicate their trust in the ability of other members and the TACFIRE computer to perform a fire mission in a timely and correct manner as specified in technical manuals for TACFIRE.	For each of the tasks and subtask elements identified in tables 3, 5, and 7, the team members involved will indicate their trust in the other members and the TACFIRE computer to perform in a timely and correct manner as specified in technical manuals for TACFIRE. Applies to each enabling objective: These objectives apply to tasks 1.0-6.0, including each subtask element as applicable for both automatic and manual modes. Conditions of the objective include the member involvement, team structure, and class of interface defined on tables 3, 5, and 7.
Aggressiveness	Team members of the Bn FDC will indicate willingness to initiate actions, communications, and procedures during a fire mission when the timeliness and correct performance of the mission require it. Initiative will be indicated as being within the bounds of team member roles.	For each of the tasks and subtask elements identified in tables 3, 5, and 7 the team members involved will indicate willingness to initiate actions, communications, and procedures when the timeliness and correct performance of the mission require it.

2. The critical factors in a scenario-driven team training process include perception and expectation about jobs, coordinated and compensating task/team member interaction, and the priorities of mission events.

The emphases underlying both assumptions are twofold. First, there must be adequate incorporation of team member interactions in the instructional strategies underlying the scenarios. Second, the team member interactions must be placed in a simulated tactical environment. It is believed that rich combat representations built into the scenarios are critical to the involvement of the trainee at more than a drill and practice level. The following subsections on scenario sequencing and scenario structure will address the issues in more detail.

Scenario Sequencing

In order to match the entry level and projected accumulative learning of the subjects with the variety of team interactions present in a continuum of tactical combat situations, it was necessary to develop the scope and sequence of scenario presentations. In essence, this translated into four levels of training for the demonstration/evaluation. These levels were (1) individual training, (2) beginning team training, (3) integrated team training, and (4) emergent team training. The scope and sequence reflected both the theoretical underpinning as well as the implementation of the team ISD model. That is, it was recognized in the literature that a certain level of individual competence had to be attained before the students could effectively be trained as team members. Secondly, the team ISD model is in part based on the assertion that both established and emergent situations which reflect the actuality of the team operational situation must be maintained in the training scenario. The scope of each scenario within the training progression incorporates increasing complexity in regard to team member roles, information flows, decision and

problem solving requirements, coordination activities and tactical evolutions. The following paragraphs discuss each level of the scenario presentation.

Individual Training. As stated in the above paragraph, the project team assumed that a minimum level of individual competence must be achieved before team training can be effective and efficient. The first instructional sequence was designed to this objective. The lesson included lecture/discussion sessions and an individually-oriented CAI scenario. The lecture/discussion aspect of the instruction centered on teaching the basic operational doctrine, rules, and guidelines to be followed by the students throughout the team instructional sequences. Student handouts included basic definitions and explanations of the operations in which they would be involved, maps and statements of the rules with which they would have to comply to correctly respond to various learning events. This pre-CAI instructional event occupied approximately 20 minutes of the demonstration/evaluation session. Upon completion of that session, the students were introduced to the first CAI lesson. This lesson covered the rules, regulations, and procedures for conducting a TACFIRE fire mission. CAI instructional strategies included drill and practice to criterion levels, tutorials, individual feedback, and a debriefing session for those subjects selected to function as a team.

Beginning Team Training. The second sequence of scenarios comprised the beginning team lesson. This lesson introduced the subjects, for the first time, to coordinated sequence drills. In addition, problem complexity routines increased by number of missions, target spread, information flows (including erroneous information) and team problem solving activities. The COLT^2 strategies for the beginning team lesson also included individual feedback as well as team debriefing. Again, the beginning team training essentially was doctrine training on TACFIRE operations, focusing on the established team roles.

Integrated Team Training. The third level of scenarios represented integrated team training. The integrated team training scenarios were originally designed to incorporate instructional strategies which related to coordination and compensatory interactions. That is, the team members were to be presented with multiple tasks which were to be integrated through specific decision processing which would lead to the allocation of team resources. This instructional sequence was to represent the multiple mission and task operations which in actuality characterize artillery operations. Thus, the team would have to demonstrate both individual and team coordinated (compensatory) behaviors throughout the lesson. The decisions base would be dynamic, primarily based on individual performances and mission-task priorities. The operational conditions for the integrated team training scenario (e.g., equipment, personnel, logistics, etc.) were presented in a favorable tactical evolution.

However, the difficulty of programming PLANIT to handle the complex branching and communications required precluded the full implementation of this scenario. In actuality, the scenario was more individually oriented, characterized by multiple task presentations.

Emergent Team Training. The final sequence of scenarios was for emergent team training. These scenarios were designed to incorporate all instructional strategies previously employed--specifically emphasizing those of major complexity within the integrated team training scenarios. Further, the instructional strategies would incorporate operational fluctuations (positive and negative) and combat catastrophes. Again, however, the development of the scenarios was limited by the time frame for dealing with subjects and the capability of PLANIT to handle the complex switching, branching, review and communications required for intrateam manipulation of the tasks.

The actual instructional sequence prepared for the subjects included the presentation of a series of four tactical situations in which decisions were required regarding the assignment of member roles and the structuring of the team. After the decision points were passed, a series of questions related to team member attitudes about the operation were asked of both team members. Then the team members received an evaluation and assessment of the decision, with hypothetical performance outcomes.

Scenario Structure

The scenario structure for each training level was similar. Basically, each sequence started with a description of the tactical situation. This included all relevant information necessary for the FDC team to effectively conduct a fire mission. Second, the tasks requiring student execution were presented. Third, there was a phaseout which presented the subjects with a synopsis of the effects of the fire missions that they had conducted. Finally, for each of the subject teams there was a debriefing session. This session included a discussion of the individual performances throughout the fire mission and an assessment of the overall team performance. In turn, subjects were allowed to discuss their own role interactions and to discuss any team problem solving strategies they may implement in future lessons.

PLANIT Implementation*

A primary objective of this investigation was to assess the applicability and potential of the PLANIT system for $COLT^2$. Under the aegis of ARI PLANIT has been modified by Dr. Charles H. Frye of the Northwest Regional Educational Laboratory to support team training. The team extension of PLANIT was based

*For the demonstration, PLANIT was installed on ARI's CDC 3300. The installation used 84K bytes of core memory. The remaining program was divided into 18 partitions; thus, very heavy swapping of overlays resulted when using DIAL. CALC, and the common matrix.

on a logical derivation of possible language requirements for team training without the benefit of an experience of actual implementation attempts. The present study offered the first opportunity for determining the adequacy of this initial PLANIT team training version.

The team training directives implemented in PLANIT and used in the lesson development of this study were: (1) a common lesson matrix that could be defined, retrieved or updated (the FETCH and PUT directives, already a part of PLANIT, are used to manipulate the common matrix), and (2) use of the DIAL directive while in the CALC mode or as a CALC command in the lesson scenario. Four team training CAI considerations are tied to these directives. They are: (1) storage and retrieval of information related to scenario events, communications, learning events sequences, and student performance via the common data base, (2) initialization of lessons, (3) synchronization of team members to scenario events, and (4) communications among team members. The remainder of this subsection discusses each of these major considerations and how they were implemented in the lessons via the PLANIT directives.

Common Data Base. The common data base in PLANIT was adequate for implementation of the instructional strategies, for the tracking of events, event sequencing, and synchronization of subjects.

The use of the common data base for these purposes involves only a matter of appropriate design of the matrix in PLANIT. However, if the team training lessons of the future are to be implemented by Army instructional personnel for example, then it may be desirable to provide commands with parameters to set the values of a common data base indicating sequences of events, automatic designation of terminal values, and synchronization requirements.

Initialization. The problem of initializing a common lesson base for multiple students has been addressed in the team version of PLANIT. Frye (1976) describes the procedures required.

```
FRAME 1.00 {D}

G2. CRITERIA
C:SET MATRIX{X,20}  C:SET X{1}=TERMINAL  C:PUT X
F:@TYPE 'HI'TO CONNECT WITH THE OTHER PLAYER.

FRAME 2.00 {Q}

G3. ANSWERS
A  HI

FRAME 3.00 {D}

G2. CRITERIA
C:FETCH X
IF X{1} EQ TERMINAL
F: NOT THERE YET.  WAIT A MINUTE AND TRY AGAIN.  B:2
ELSE C:SET HIMX{1}  C:X{1}TERMINAL  C:X{2}=TIME  C:PUT X
C:PRINT 'OK, YOU ARE LINKED WITH TERMINAL ';HIM ROUND{0}
IF TERMINAL IS HIM C:SET MINE=3  C:SET HIS=4
ELSE  C:SET MINE=4  C:SET HIS=3
```

In the above example, the two players will be connected to the team scenario by both GETting the same lesson name. Beginning with the third statement in frame three, the logic is set up such that the most recently answering terminal will be identified by number in the first common entry, and the time of the answer in the second entry. The item HIM will be the terminal number of the other player and can be used in the DIAL command, e.g.:

```
DIAL HIM  YOU AND I ARE NOW TEAMED.
```

The third and fourth entries of the common area are set up for communicating code values, and the items, MINE and HIS are defined properly so that separate entries will be assigned. MINE and HIS would be used frequently to subscript the matrix X after a FETCH or between a FETCH/PUT update sequence.

The next example will perform the initial acquisition for three team members. This logic can be extended to as many members as desired. Having acquired all members of the team, a branch is made to another lesson where each team member will be in a different lesson. The common lesson matrix will be valid for all three lessons. Each lesson will then proceed according to the role of that particular team member:

```
FRAME 1.00 {D.}

G2. CRITERIA
C:SET MATRIX{X,20}
IF LINK{10} NQ 0  C:PUT X  C:LINK{10}=0
ELSE  C:LINK{10}=1  C:FETCH X  C:LINK{10}=0
IF X{1} NQ 0 FOR{I=1,3}
F:SORRY, ALL POSITIONS ARE TAKEN.  ANOTHER TIME.  C:FINISHED
ELSE F:@ARE YOU RED, YELLOW OR BLUE?

FRAME 2.00 {Q}

G3. ANSWERS
} KEYWORD ON
A RED
B YELLOW
C BLUE

G4. ACTIONS
A C:SET COLOR=1
B C:SET COLOR=2
C C:SET COLOR=3
- R:ANSWER ONE OF THE THREE OR TYPE 'FINISHED.'

FRAME 3.00 {D}

G2. CRITERIA
IF X{COLOR} NQ 0 F:SORRY, WE HAVE ONE OF THOSE ALREADY.
F:CHOOSE ANOTHER.  B:2
ELSE  C:FETCH X  C:X{COLOR}=TERMINAL  C:X{19}=TERMINAL
C:X{20}=TIME  C:PUT X  B:5

FRAME 4.00 {Q}

G2. TEXT
DON'T HAVE ALL THE PLAYERS YET.  TYPE 'GO' AND I'LL
CHECK AGAIN.

G3. ANSWERS
A  GO

FRAME 5.00 {D}

G2. CRITERIA
C:FETCH X
IF PROD X{I} FOR{I=1,3} EQ 0 B:4
ELSE  F:OK, LET'S GO.  B:RED, YELLOW, BLUE: COLOR
```

In this example, the first entry of common has the terminal number of RED, the second has YELLOW, and the third has BLUE. The 19th entry shows the number of the most recent terminal to answer and the 20th entry shows the time of the answer. Finally, a branch is made to one of the three lessons, each of which presumably contains logic that pertains to a particular player.

Synchronization. During team training interactions, it is frequently necessary to determine where each individual student is in the sequence, and, depending on the instructional sequencing design, it may be desirable to stop a student at some point while another team member catches up or performs another action which will influence or be dependent upon another team member. Thus, two important aspects of synchronization are derived. First, it is necessary to test for the occurrence of events or team member status in the instructional sequence. Second, it is necessary at times to hold a team member in place. In both cases, student progress (events) must be tested in order to properly sequence member interactions. Several ways of testing for events can be illustrated with examples from the lesson implemented for the demonstration and from examples extracted from Frye (1976).

Further, the initialization examples previously presented also showed instances of synchronous operations since no player is allowed to proceed until all have signed into the system. Another example of synchronization, provided by Frye, follows. In this case no one is allowed to proceed beyond frame 10 until all are together.

```
FRAME 8.00 {D}

G2. CRITERIA
C:FETCH X   C:X{COLOR+10}=10   C:PUT X
F:THERE MAY BE A SHORT DELAY UNTIL EVERYONE CATCHES UP.
```

```
FRAME 9.00 {D}

C:FETCH X
IFX{I} EQ 10 FOR{I=11,13}    B:11

FRAME 10.00 {Q}

G2. TEXT
TYPE 'GO'

G3. ANSWERS
A   GO

G4. ACTIONS
F:OK, WILL CHECK   B:9
```

In the 'brassboard', students interacted with the system and each other to simulate the sequence of events comprising a fire mission. Frequently, the FDO was required to take an action; the FDS evaluated that action; the FDS then was required to take an action himself. This required holding the FDS in place until the FDO had taken an action and the FDS had received a communication from the FDO stating what the action was.

For example, a series of frames of the sort below was presented. Each required the above described sequence of responses by the FDO and FDS.

```
                FIRE MISSION
          RED THUNDER 13 - THIS IS WILD HORSE
    6 - FIRE MISSION.  INFANTRY PLATOON IN
    THE OPEN, WILL ADJUST FIRE.
          TGT NO. IS INFANTRY1.
          TAKE ACTION
          1. PAGE           4. CORRECT
          2. FIRE           5. PROBLEM
          3. CLEAR
```

Each frame was seen by both team members. The FDO answered first, and his action was communicated to the FDS. However, his message could be transmitted only after the FDS had received the complete display as shown. Furthermore, the FDS could be allowed to respond only after receiving the FDO's message. The lesson sequence to control this synchronization was as follows:

```
FRAME 5.00 {D}  LABEL=READY
GROUP 2
C:FETCH X  C:X{1,1,1}=RESPONSE  C:X{3,3,1}=X{3,3,1}+1  C:PUT X
IF  X{3,3,1}  LS  S{3,3,2}  B:SYNC {X{3,3,1}
IF  X{3,3,1}  EQ  X{3,3,2}  B:8
ELSE  F:|$


FRAME 6.00 {Q}
GROUP 3
Ø WAIT 5
A   AZS
GROUP 4
-A   F:STANDBY


FRAME 7.00 {D}
GROUP 2
C:FETCH X
IF X{1,4,2} EQ 0 F:YOUR TEAMMATE IS GONE.  B:4.5
IF X{3,3,1} GR X{3,3,2}  F:|$   B:6


FRAME 8.00
```

"CANNED MESSAGE FRAME" - to be described in following subsection.

```
FRAME 8.10
GROUP 2
B:SYNC{X{3,3,1}}

FRAME 9.00 {Q}
GROUP 2
            FIRE MISSION
      RED THUNDER 13 - THIS IS WILD HORSE6 -
FIRE MISSION.  INFANTRY PLATOON IN THE
OPEN, WILL ADJUST FIRE.
      TGT. NO. IS INFANTRY 1.
      TAKE ACTION
      1. PAGE           4. CORRECT
      2. FIRE           5. PROBLEM
      3. CLEAR
GROUP 3
      I+1
      2 4 WITHIN 2
GROUP 4
1     F: YOUR ANSWER IS RIGHT -- EVERYTIME
      F: YOU RECEIVE THE FM NOTIFICATION YOU 'PAGE'
      F: TO CHECK FOR A WARNING.  B:READY
2     F: THE CORRECT RESPONSE IS 'PAGE'. YOU
      F: MUST 'PAGE' THROUGH THE MESSAGE TO
      F: CHECK FOR A WARNING.  B:READY
-     R: CHOOSE A NUMBER FROM THE LIST
```

It should be noted that in this sequence (part of the FDO's lesson at the beginning team level) a branch to the frame labeled "READY" is made after a legitimate response. READY is frame number 5.00. Its major purpose is to increment a counter stored in the common matrix for tracking the FDO's position in the lesson and comparing it to the FDS lesson position. Cell 3,3,1 in matrix X served this purpose for the FDO. Cell 3,3,2 was used for tracking the FDS, and a similar frame sequence existed in the FDS lesson. In frame 5.00, if the FDO and FDS had been at the same point in the lesson, a branch to frame 8 would have been made to transmit a canned message. Frame 8.1 was then executed to a branch to the frame number in an array "SYNC" designated by the value of 3,3,1. If the value of 3,3,1 was less than 3,3,2, the FDS had already been sent the message and a similar branch could be made through the array SYNC to allow presentation of the next frame to the FDO. If neither of these two conditions were true (3,3,1 was greater than 3,3,2) the FDS was behind the FDO and not ready to receive the message. In this case, frame 6.0 would be executed to inform the FDO to standby. Frames 6.00 and 7.00 form a standby loop to hold the FDO until the FDS could get into proper lesson position.

Communications. Two forms of communicating between team members are available in the team version of PLANIT. The DIAL directive is used for both forms. First, team members may use DIAL to initiate, compose, and exchange messages at the terminal. Second, messages can be written into the lesson. Having assigned terminal members to variable CALC names, targets of the 'canned' messages can be designated in the scenario. The recipient of the message will see the sender's name as part of the message. However, the sender would not know that he is transmitting a message unless he is told.

For the COLT[2] lessons, four aspects of communications were important: (1) control, (2) content, (3) timing, and (4) recording. Control relates to

which team members initiate messages and which receive messages. Content is the subject of the message. Timing relates to when messages are sent. Recording of messages relates to the storing of the above three for evaluative purposes. If the terminal oriented DIAL directive had been utilized, none of these four aspects would have to be controlled. For this initial investigation into COLT², it was desirable to have a capability for directing and storing communications. Therefore, the DIAL messages were written into the lessons.

A series of five messages representing the array of possible FDO responses at a decision point were coded into the lesson. The message to be transmitted to depended on the decision made by the FDO. An example of the message frame follows:

```
FRAME 8.00 {P}
GROUP 2
B:M1,M2,M3,M4,M5;X{1,1,1}
M1:DIAL FDST I THINK 'PAGE' IS THE RIGHT ANSWER. B:TAIL
M2:DIAL FDST I THINK 'FIRE' IS THE RIGHT ANSWER. B:TAIL
M3:DIAL FDST I THINK 'CLEAR' IS THE RIGHT ANSWER. B:TAIL
M4:DIAL FDST I THINK 'CORRECT' IS THE RIGHT ANSWER.  B:TAIL
M5: DIAL FDST I DO NOT KNOW RIGHT ACTION, YOU CHOOSE.
TAIL:
```

Prior to reaching this frame in the lesson, the value of cell 1,1,1 in the common matrix was set to a value determining which message (M1, M2, M3, M4, M5) was to be sent to the FDS terminal (FDST) by the FDO. The event value determining the message in this case was the action, selected by number, to be taken in the fire mission. X(1,1,1) was therefore set to the value of the PLANIT primitive response. The conditional branch statement in line 1 Group 2, Frame 8, above therefore selects the message to be sent to the FDS appropriate to the FDO's action. This capability of PLANIT to select the particular message is probably adequate for most purposes where the message sequences are pre-prepared as part of the lesson data base.

BRASSBOARD DEMONSTRATION/EVALUATION

The purpose of the brassboard demonstration/evaluation was twofold. First, an assessment of the instructional strategies sampled in the scenario was accomplished. The output of this aspect of the study is (1) a report of the findings, and (2) research recommendations for instructional strategy, scenario, and job/task analysis issues which remain unaddressed. The second function served by the "pilot study" was the assessment of the applicability of the PLANIT language for team training. The output of this facet of the study is a set of recommendations for PLANIT language extensions necessary for a full team training capability. The remainder of this section will contain a description of the brassboard demonstration/evaluation implementation procedures and the findings of the study. The following section provides a more detailed discussion of the implications of the findings.

Subjects

The subjects were 40 Army enlisted men from commands in the Washington area. The ranks of the subjects ranged from E-3 to E-7, with more than 75 percent of the subjects being E-4's or E-5's. A variety of military occupational specialties (MOS) were represented. However, a majority of subject MOS's were related to administrative and clerical jobs. Table 5 presents a summary of other characteristics of the subjects.

Table 5. Summary of Subject Characteristics

Variable	Mean	S.D.
Age	25.3	4.8
Years in Service	5.3	4.2
Educational Level	13.0 (years)	1.4
GT	114.8	11.4

Design

The demonstration/evaluation was conducted in four steps. During the initial step, subject biographical data was collected, and two individual difference scales were administered. These scales were the Rotter I-E Scale (Rotter, 1966) for assessing locus of control and the A-Trait section of the State-Trait Anxiety Inventory (Spielberger, Gorsuch and Lushene, 1970). After completing these scales, students were assigned to work through the subsequent instructional materials on either a team or an individual basis. This assignment was conducted on a random basis. Additionally, team members were assigned roles; that is, they were selected to undergo the instruction either as a fire direction officer or as a fire direction sergeant. Again, the assignment of roles was conducted on a random basis.

Step 2 involved presenting the subjects with preliminary background information regarding subsequent tasks that they would be performing. Primarily, this lesson taught the subjects how to conduct the basic fire mission. The instruction was lecture/discussion with students having handouts and exercises to work through. Upon completion of this phase of Step 2, the subjects were introduced to their first computer-assisted instruction lesson. The first lesson was individually based, with all subjects going through

identical information sequences with no coordinated (team) activities required. At the conclusion of this lesson, the subjects took a 15 item test presented by the computer.

After subjects had been familiarized with the procedures for conducting a fire mission, the team began work on their first coordinated instructional task. The basic team task requirements were identical for all teams and consisted of sequences of increasingly complex fire missions. The subjects operating in an individual mode were presented with the same materials that were presented to the teams. However, subjects were not required to coordinate their activities with another team member. There were 39 student executions (decisions) required in this lesson. At each execution point, subjects were required to make a procedural response within a tactical fire mission context. During the lesson individual feedback was presented to all subjects. At the conclusion, the teams were debriefed and allowed to discuss role assignments and team interactions.

Step 3 focused on the integrated team lessons. As stated in the prior section, the integrated team materials were not presented to the subjects in the manner in which originally designed because of the software limitations. Originally, the integrated team lesson was to confront the team leader and the other team member with a continuum of tactical role assignment decisions. After each decision, to be made either individually by the team leader or in concert with his fellow team member, specific tasks had to be performed by the team members. At the conclusion of each set of tasks, a new tactical situation would arise where multiple tasks again would have to be integrated and team resources allocated. In actuality, the lessons did not include the decision making properties. There were a combination of tasks to be performed, but events were sequenced by the lesson rather than the learner. The only difference

in strategies between the team and individual subjects was the fact that at certain points throughout the instruction, the teams were coordinated and did receive team feedback on performance.

The last phase consisted of the emergent team lessons. The materials were presented as described in the prior section. Primarily, they constituted a series of tactical situations in which specific artillery fire mission problems were presented. At each of these decision points, both the FDO and FDS were allowed to respond as to what action they would take to resolve the problem. In the team environment, however, the decision made by the FDO was the one that counted. After each decision was made, both team and individual subjects were presented with a series of questions relating to their confidence in the decision, role assignment, and projected team performance.

At all steps drill, problem complexity in sequencing, and feedback strategies were similar. The teams, however, were working through coordinated sequence drills; whereas, individuals were not. Another major difference was that team debriefings were more extensive, with team members being apprised of each other's scores and having the opportunity to discuss future role assignments.

Measures

Basically, three categories of measures were collected: (1) entry behaviors, (2) performance ratings, and (3) attitudes. Entry behaviors included the variables of age, years in service, educational level, GT, military occupational speciality, rank, stress anxiety, and locus of control.

Locus of control was assessed by means of the Rotter I-E scale. Locus of control is a theoretical construct that refers to the degree to which individuals believe that reinforcement is either directly contingent upon their own behaviors

or independent of them and attributable mostly to chance. The former type of belief is ascribed to people at the internal end of the locus of control continuum and indicated by low scores on the Rotter I-E scale. Individuals with high scores are at the external end of the locus of control continuum.

There were two reasons for selecting locus of control as an individual difference variable in the present research. First, the available evidence indicates that locus of control is sufficiently consistent and powerful in its effects upon behavior to justify its use as a basis for selection of team members. Second, although research findings regard the influences of locus of control on classroom behavior and achievement as equivocal, where significant differences have been attained, higher achievement generally tends to be positively correlated to an internal orientation, particularly under learner control methods. (Daniels and Stevens, 1976; Nord, Connelly and Daignault, 1974). Considering that the instructional task investigated in this study is computer based and has a potential for allowing students an extensive amount of individual control, it was reasoned that locus of control could serve as a meaningful predictor of task achievement.

The second individual difference scale employed in this study was the trait anxiety scale developed by Spielberger. The state-trait anxiety theory as formulated by Spielberger (1966) emphasizes the practical and theoretical importance of differentiating between anxiety as a relatively stable, generalized personality trait and as a situationally dependent state or condition that varies in intensity over time. The subsequent development of the state-trait inventory (Spielberger, et al., 1970) was intended to establish a means for characterizing individuals in terms of both dimensions. These types of findings have definite value from the standpoint of allowing one to forecast with reasonable accuracy how students tend to react to stressful stimuli over time in a variety of situations.

On the basis of the previous research, the following judgments were made concerning the role of anxiety variables in the present investigation.

1. The available literature on anxiety provides a strong empirical and theoretical rationale for using a trait anxiety variable as a basis for predicting student performance under differing modes of instruction (e.g., team vs. individual).

2. With regard to the use of trait anxiety as a predictor variable, it was assumed that some students would find the coordinated structural activities significantly more stressful than would others. Anxiety theories suggest that the probable consequences of such reactions would be greater distractibility during acquisition and lower performance on the final test. It was therefore reasoned that anxiety variables would provide a useful basis for selecting and refining instructional strategies, particularly given team and individual instructional sequencing.

Performance Measures. Within each instructional lesson, performance scores were collected. At the conclusion of the individual lesson, there was a 15 item quiz. During the beginning team lesson, there were 39 decision points with student response data being collected at each point. Student performance on the integrated lesson was evaluated at decision points within fire missions and by a second criterion qui of 10 items. Finally, in the emergent team lesson, there were four decision points about which student responses were collected. Response time was kept, but it was more a measure of machine response time than student reaction.

Attitude Measures. Attitude measures were collected only during the integrated team lesson. These took the form of seven confidence and role assignment related items which were administered subsequent to each tactical decision being made.

Findings

Means and standard deviations for subject characteristics, individual difference scales, and performance scores are presented in Table 6 by total group, team FDO, team FDS, and the individual instruction subjects (IND). Although the subjects were randomly assigned to groups there were significant differences between groups in regard to some variables. The FDO group had approximately one-half year more of education ($\overline{X} = 13.31$) than did the FDS group ($\overline{X} = 12.75$) and the IND group ($\overline{X} = 12.75$). The t value for both differences is 6.098, $p > .001$. The GT score for the FDO group was significantly greater ($t = 6.936$, $p > .001$) than the FDS GT, which in turn was significantly higher ($t = 8.113$, $p > .01$) than the GT score for IND.

There were also significant differences between groups for the two individual difference scales. The FDS T-anxiety rating was greater than both the FDO ($t = 15.856$, $p > .01$) and the IND ($t = 13.079$, $p > .01$) groups. There was no difference on the T-anxiety rating between FDO and IND subjects. The Rotter results were similar to the T-anxiety scores; that is, the FDS rating was significantly higher than the scores for FDO ($t = 4.190$, $p > .01$) and the IND ($t = 2.851$, $p > .01$) groups. Thus, the FDS group was characterized as demonstrating a higher level of Trait anxiety and a greater tendency toward an external locus of control.

On initial performance, a 15-item quiz concluding the individual CAI lesson (see Ind. Score in Table 6), the FDO group scored significantly higher than the FDS ($t = 14.286$, $p > .001$) and the IND ($t = 12.806$, $p > .01$) groups. Both FDS and IND groups made significant gains in their scores on the beginning team measures. During that lesson, FDS subjects were coordinating their responses with the FDO subjects. IND subjects received the same instructional materials but were operating alone. In the integrated lesson, FDS and FDO

Table 6. Means and Standard Deviations for Independent Variables and Performance Scores

	Total (N=40) X	(S.D.)	FDO X	(N=16) (S.D.)	FDS X	(N=16) (S.D.)	IND X	(N=8) (S.D.)
Years In Serv.	5.33	(4.19)	5.63	(4.52)	3.75	(3.28)	7.88	(6.21)
Educ. Level	12.98	(1.39)	13.31	(1.35)	12.75	(1.34)	12.75	(1.63)
GT	114.77	(11.41)	117.93	(13.53)	114.58	(6.49)	109.12	(14.05)
Anxiety	34.28	(6.73)	32.56	(6.34)	37.19	(6.45)	31.88	(6.74)
Rotter	6.64	(4.44)	6.25	(5.13)	7.13	(3.96)	6.42	(4.12)
Ind. Score	0.77	(0.18)	0.83	(0.14)	0.73	(0.17)	0.72	(0.20)
Beg. Score	0.82	(0.10)	0.83	(0.10)	0.83	(0.07)	0.79	(0.13)
Int. Score	0.76	(0.22)	0.78	(0.23)	0.71	(0.24)	0.79	(0.15)
Int-1 Score	0.72	(0.22)	0.77	(0.22)	0.66	(0.25)	0.73	(0.15)
Int-2 Score	0.77	(0.21)	0.80	(0.22)	0.75	(0.24)	0.76	(0.14)

scores dropped while the IND scores were maintained at the same level as the beginning team lesson scores. The only group to significantly increase its score from the individual lesson to the integrated lesson was the IND ($t = 2.083$, $p > .05$). In fact, both FDO and FDS scores dropped from the individual lesson to the integrated lesson.

Figure 2 illustrates the performance of the groups. It is interesting to note that the coordinated training presented to the team subjects in the beginning lessons did not seem to increase their individual skills substantially. As each set of lesson materials was gauged to be more difficult, it cannot be stated absolutely that the team training had no effect on individual proficiency. The comparison of FDO and FDS performance with IND is dramatic, however. The continuous individual training appears to lend itself to systematic performance increments. On the other hand, coordinated behavior apparently leads to better achievement on specific established tasks, but both FDO and FDS subjects

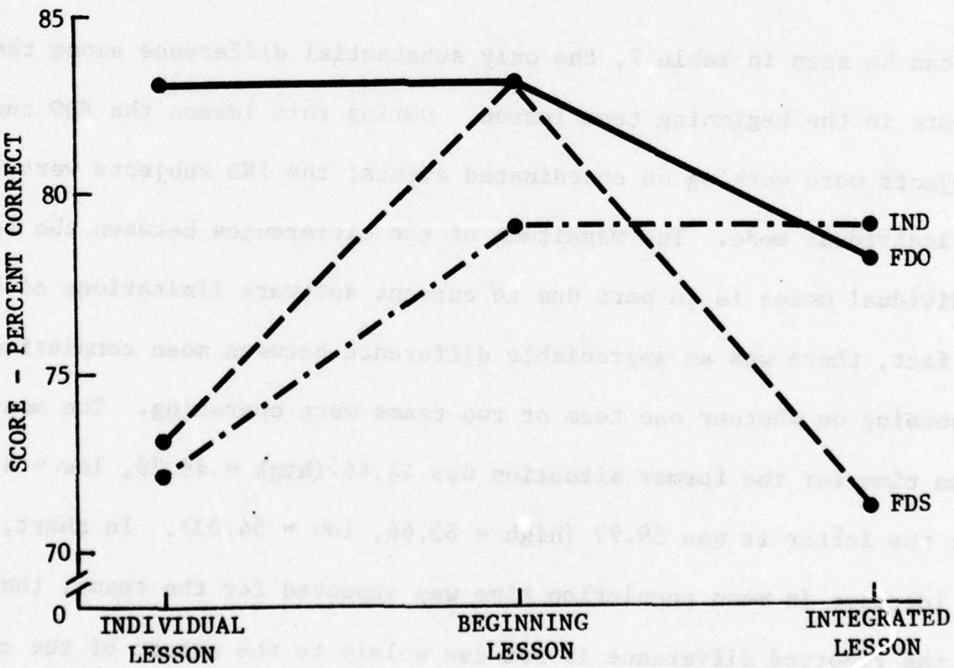

Figure 2. Lesson Performance By Group

demonstrated substantial performance decrements on subsequent individually-oriented tasks. The findings, limited in their inferential power because of the small number of subjects and the anecdotal nature of the evaluation, indicate that there are differences between the effectiveness of team and individual instruction in regard to what types of behaviors are being learned.

In addition to performance scores, lesson completion times were collected. Table 7 presents the means of these times by group.

Table 7. Mean Times (minutes) For Lesson Completion

All Subjects	FDO	FDS	IND
Ind. Lesson	27.93	26.28	27.00
Beg. Lesson	54.81	54.81	24.51
Int. Lesson	21.45	19.02	19.56

As can be seen in Table 7, the only substantial difference among the groups occurs in the beginning team lesson. During this lesson the FDO and FDS subjects were working on coordinated events; the IND subjects were working in an individual mode. The magnitude of the differences between the team and individual modes is in part due to current software limitations of PLANIT. In fact, there was an appreciable difference between mean completion times depending on whether one team or two teams were operating. The mean completion time for the former situation was 44.46 (high = 49.29, low = 41.64); for the latter it was 59.97 (high = 63.66, low = 54.03). In short, although an increase in mean completion time was expected for the teams, the magnitude of the reported difference is not due solely to the nature of the coordinated activity.

Correlational Analysis. The correlation coefficients and significance levels for the independent variables and performance scores are presented in Table 8. Five independent measures and three performance scores are represented in the matrix.

Of the five independent variables, GT correlated more highly and more consistently with task performance than did any of the other variables. Rotter correlated significantly ($r = .34$, $p = .016$) with the individual lesson score but the correlation coefficient diminished over the other two lessons. The same was true of educational level. This variable had a relatively high correlation with the individual lesson score ($r = .43$, $p = .003$); then dropped appreciably in magnitude and had a direction change. As was expected, anxiety negatively correlated with all task performance measures.

In addition to product moment analysis, stepwise regressions were run against the dependent variables of individual lesson score and beginning lesson score (see Tables 9 and 10). The independent variables regressed against individual lesson score were years in service, educational level, GT, anxiety, and Rotter. The beginning lesson score regression also included the individual lesson score as an independent variable.

As can be seen in Table 9, the multiple correlation coefficients are reasonably substantial for all three groups. The order and magnitude of the independent variables change across groups, however. For FDO and IND, Rotter and GT account for the preponderance of the explained variance. For FDS, the two variables contribute substantially less to the multiple R.

The regression against the beginning team score also resulted in substantially high multiple correlation coefficients. What is interesting is the comparison of the two regressions. As anticipated, the order and magnitude of the independent variables for both IND regressions are similar. Rotter

Table 8. Correlation Coefficients and Significance Levels for Independent Variables and Performance Scores*

	006 Educ. Level	007 GT	008 Anxiety	009 Rotter Scale	010 Ind Score	012 Beg Score	016 Int Score
005 Years in Service	-.16 (.156)	-.17 (.167)	-.12 (.231)	-.27 (.045)	-.04 (.403)	.22 (.089)	-.09 (.304
006 Educ. Level	1.000	.15 (.198)	-.18 (.133)	.28 (0.43)	.43 (.003)	-.06 (.350)	.07 (.324)
007 GT		1.000	-.28 (.054)	.31 (.036)	.21 (.109)	.42 (.006)	.35 (.021)
008 Anxiety			1.000	-.35 (.014)	-.21 (.095)	-.16 (.166)	-.20 (.117)
009 Rotter				1.000	.34 (.016)	.16 (.159)	.09 (.306)
010 Ind. Score					1.000	.28 (.039)	.28 (.04)
012 Beg. Score						1.000	.29 (.041)

*Figures in brackets are levels of significance

Table 9. Summary of Stepwise Regression. Dependent Variable: Individual Lesson Score

Variable	Multiple R	R^2	R^2 Change	Simple R	B	Beta
			Group: FDO			
Rotter	.50	.25	25	.50	.02	.06
GT	.56	.31	6	.46	.01	.08
Education	.58	.33	2	.03	-.53	-.33
Years in Service	.59	.35	1	-.33	-.26	-.53
Anxiety	.65	.43	8	-.39	-.17	-.50
			Group: FDS			
Education	.68	.46	46	.68	1.26	.66
GT	.70	.49	3	.27	.08	.19
Rotter	.70	.49	0	.07	-.04	-.06
			Group: IND			
Rotter	.73	.53	53	.73	.82	1.01
GT	.83	.69	16	.36	.13	-.47
Years in Service	.88	.77	8	.08	-.20	-.35
Anxiety	.91	.82	5	-.34	.14	.29
Education	.91	.83	0	.45	.16	.07

Table 10. Summary of Stepwise Regression. Dependent Variable: Beginning Lesson Score

Variable	Multiple R	R^2	R^2 Change	Simple R	B	Beta
			Group: FDO			
GT	.56	.31	31	.56	.12	.41
Education	.61	.37	7	-.18	-.96	-.32
Anxiety	.67	.44	7	-.53	-.23	-.37
Ind. Score	.68	.46	2	.18	-.34	-.18
Rotter	.68	.46	0	.22	.06	.08
			Group: FDS			
GT	.46	.21	21	.46	.20	.51
Rotter	.59	.35	14	-.29	-.24	-.38
Education	.66	.43	8	-.26	-.95	-.54
Ind. Score	.71	.51	8	.13	.36	.39
Anxiety	.72	.52	1	.13	-.05	-.12
			Group: IND			
Rotter	.58	.34	34	.58	.63	.45
Anxiety	.60	.36	3	-.20	.13	.15
GT	.61	.37	1	.12	.11	.22
Ind. Score	.62	.39	2	.48	.57	.33
Education	.63	.40	1	.18	-.41	-.11

and GT consistently account for the multiple R. The only difference in order is the introduction of anxiety as contributing more to the explained variance than GT for the beginning team score. The magnitude of all independent variables is less in the second regression. As stated earlier, the similarity in the ordering of the independent variables was expected as IND subjects were working in a similar mode during both lessons.

On the other hand, the FDO and FDS subjects were working in a coordinated task environment during the beginning team lesson. As one can see, in comparing the regressions for these groups the order and magnitude of the predictor variables changes significantly from individual lesson to beginning lesson. In fact, the order is nearly reversed. For example, the orientation measure (Rotter) was ordered first for the FDO individual lesson score. For the FDO beginning lesson score it was ordered last. The R^2 contribution changed from .25 to 0. In addition, GT and Rotter accounted for only 3% of the R^2 for the FDS individual lesson score. For the FDS beginning score, the contribution of these two variables increased to 35%.

In short, there appears to be little stability among independent variables for explaining variance in scores between individual and team contexts. It should be noted, however, that the analyses were based on the individual characteristics of the team members. The composite of the teams was not identified and used as an independent variable. It may well be that by analyzing combinations of member characteristics, more systematic explanations of task performance could be derived.

<u>Role Perception and Attitudinal Measures</u>. Data collected during the emergent team lesson included subject responses to four tactical scenario situations. In each of the four cases, the FDO, FDS, and IND subjects were required to make a decision regarding how they would structure the team in

order to perform the task involved in the scenario. In regard to the IND subjects, the decision-making process itself was artificial in that the individual team member had neither worked in a team mode during any of the previous lessons nor would be working with another individual during the emergent team lesson. After each decision was made, subjects were administered seven items which related to their confidence in the decisions and their perceptions of the roles of the team members.

Table 11 presents the distribution of decision responses by FDO, FDS and IND. In all cases, once the decision was made subjects received hypothetical feedback reporting the efficacy of the decision that they had made. As can be seen in Table 11, the three responses available to the subjects were (1) to totally delegate at least one of the tasks to the FDS, (2) to delegate tasks to the FDS but provide monitoring, and (3) not to delegate any tasks to the FDS. In each case, there was a preferred response, an acceptable response and a wrong response. The rating of the responses was based on the complexity of the task situation and the criticality of the combat evolution.

The purpose of the lesson was to see how well the subjects, particularly FDO, responded to emergent tactical situations. In prior lessons, the scenarios had evolved, in essence, frame by frame with each combat situation building from prior events. In the emergent team lesson, the subjects were presented with a total picture and the parameters of particular combat situations. Also, the lesson allowed the project team to investigate the impact of a direct team feedback message. That is, in the past the team members were able to follow the performance of each other in terms of their error rates and time for responses as well as receiving team debriefings. In the emergent team lesson the feedback message only had to deal with a hypothetical outcome to a tactical decision. A third objective of the lesson was to collect data

Table 11. Distribution of Decision Responses in Emergent Team Lesson

	Delegate	Del/Monitor	Not Delegate
1st Decision			
FDO	3*	6**	1
FDS	1*	8**	1
IND	1*	5**	0
2nd Decision			
FDO	1**	6*	3
FDS	1**	7*	2
IND	2**	2*	2
3rd Decision			
FDO	4**	3*	3
FDS	3**	5*	2
IND	2**	1*	3
4th Decision			
FDO	3**	5*	2
FDS	3**	3*	4
IND	5**	0*	1

*Acceptable Response
**Preferred Response

from the individual team members in regards to their confidence in the abilities of their teammates and regarding the perception of their roles within the team context.

As can be seen in Table 11, the preferred response to the first decision was to delegate responsibility and continue to monitor the performance of the FDS. The preponderance of all subject groups selected this response. For the remainder of the decisions, the preferred response was to totally delegate at least some task comprising team mission. The feedback messages related to each of the decision choices were as follows: (1) for the preferred response, the feedback message in essence stated that the team had performed successfully and achieved their mission; (2) for the acceptable response, the feedback message stated that the team was partially successful in achieving their mission; and (3) for the wrong response, the team was told that it had failed to achieve its mission. Each of the feedback messages were more elaborate, and the feedback was constructive in that it explained the basis for the decisions as well as the feedback message. It is interesting to note in Table 11 that after the second decision when the delegate/ monitor response was giving only a partially successful score, a number of the subjects began to switch and search for the more appropriate response. However, except for the individual subjects, there was a continuing dependence on the delegate/ monitor response throughout each of the scenarios.

The responses to the seven confidence and role perception items were on a five point scale. Table 12 contains the response means and standard deviations for the confidence and role perception items. The seven items were as follows:

Table 12. Means and Standard Deviations For Confidence and Role Perception Item Responses.

Variable Name	FDO $\overline{X}$	FDO (S.D.)	FDS $\overline{X}$	FDS (S.D.)	IND $\overline{X}$	IND (S.D.)
CONFID-1	4.00	(.94)	4.20	(.92)	3.75	(.96)
CONFID-2	4.00	(.82)	3.50	(1.18)	3.75	(.96)
CONFID-3	4.20	(.79)	3.50	(1.35)	2.75	(.96)
CONFID-4	3.80	(.79)	3.50	(1.08)	2.00	(0.00)
DISCUSS-1	4.00	(.94)	4.10	(1.10)	4.25	(.96)
FDOCON-1	3.70	(.68)	3.90	(1.29)	3.75	(.96)
FDSCON-1	3.50	(.85)	3.80	(1.03)	4.25	(.96)
COMPCON-1	4.50	(.707)	3.90	(.99)	4.75	(.50)
MISDEP-1	4.50	(.85)	4.20	(1.69)	3.00	(1.41)
FDO>FDS-1	3.00	(.82)	3.40	(.70)	3.25	(1.26)

1. How confident are you in the FDO's decision? (CONFID-1,2,3,4)

2. Would you have preferred to discuss the decision with the FDO before it was made? (DISCUSS-1)

3. Should the FDO conduct fire missions? (FDOCON-1)

4. Should the FDS conduct fire missions? (FDSCON-1)

5. Should the most competent team member conduct the fire missions? (COMPON-1)

6. Who conducts the fire missions should be dependent upon the situation and the team mission. (MISDEP-1)

7. The FDO is better than the FDS at conducting fire missions. (FDO > FDS-1)

Overall, the responses led to few insights regarding individual behaviors within the team context and perceptions of the roles of the individuals. The FDO subjects demonstrated a slightly greater confidence in the decisions that they made than did the FDS subjects. Perhaps more important was that two items which received high scores were 5 and 6. Thus, both team members perceive that the structuring of the team should be based on both the competence of the individual team members as well as the characteristics of the overall team mission.

No measures were taken of the individual member's attitudes towards the lessons themselves. However, it should be noted that throughout the experimental sessions, subjects frequently commented on how interesting the lessons were. It was also noted by the project team that during the debriefing sessions, subjects took the problem seriously and quickly began to talk and behave towards one another as if they were working in an actual artillery combat environment. In short, the richness of the scenario seems to accomplish its objective of getting the subjects immersed in the training situation.

DISCUSSION

Major Team Issues

As posited in section two, there are three major team issues which should be considered in the development of a program of team training or team training research. These issues are team definition, conceptual team models, and team structure. Clearly definition criteria for categorizing multi-person operations must be established. For the present study, the criteria include (1) rigid structure, organization, and communication networks, (2) anticipation of an individual's task participation, and (3) cooperation and coordination. This definition distinguished the team from a small group and from individuals performing individual tasks in a group context.

The issue of conceptual team models is based on the situational context in which team behaviors occur. Prior research indicates that the situational context is a continuum stretching between end points which may be described as established or emergent. Team operations, characteristically, cannot be ascribed to any one point along this continuum. On the contrary, the situational context of team task performance will fluctuate all along the continuum. For training analysis, it is important to identify the critical fluctuations and to represent these in the team instructional strategies.

Team structure, serial or parallel, drives the types of team member interaction required in the performance of team tasks. Thus, the identification of the form of the team structure at each task mode is a vital input to the design of training events and to the development of team instructional strategies. Both serial and parallel structured events occur within the situational continuum.

In summary, these issues point out that team operations are comprised of a number of dimensions: the defined interrelationship of the members, the

team mission and tasks to be performed, the structure of the team vis-a-vis tasks, and environmental conditions. In the development of a training program, a job/task and training analysis that will yield the required information regarding each of these elements should be employed. In the design of a research program, each of these considerations must be weighed against the established purpose of the research. As can be seen, these major issues have driven the methodologies for achieving the stated project tasks.

A Conceptual Framework for COLT^2 Instructional Strategies

The conceptual framework is based on the definition of an instructional strategy as the product of a series of decisions which lead to the sequencing, structuring and specifying of learning events and activities. It was concluded that the information underlying these decisions is related to the characteristics of (1) the task to be learned, (2) the learner, and (3) instructional delivery system. In turn, team instructional strategies must account for the variables representing each of these dimensions within a context typically requiring multi-person interactions. That is, the coordinating and cooperative behavior present in the job must also be present in the training.

From the team task dimensions identified in the literature and through interviews with team training instructors, three categories of team learning were developed to serve as a link between team job/task analysis, team training objectives and team instructional strategies. The three learning categories were knowledge of team roles, team attitudes, and team communications. Each of the categories are discussed in greater detail in section three. It should be noted, however, that these three learning categories were derived analytically and have not been empirically tested.

Learner characteristics and strategies which are described and discussed in this report were limited to those related to individual behavior. Emphasis

was given to characteristics which impact on the ability of the student to process information, communicate, make decisions and to solve problems in a coordinated task environment. In terms of individual learner strategies, three categories were discussed in section three. The categories were made up of comprehension, memory, and problem-solving strategies.

Both learner characteristics and strategies may be used as the basis for $COLT^2$ instructional strategies in the form of preprogrammed decisions for teaching. Preprogrammed decisions frequently are a function of projected trait or entry attributes. To some extent, consideration of state characteristics such as the performance on the last task or the current state of anxiety departs from the concept of entry behavior description because these measures may be used as dynamic indicators of a learner's state. Learner characteristics and strategies, however, to be relevant to $COLT^2$ must allow for analysis of learner characteristics which will be used in designing instructional strategies and those which will be used in the instructional manipulations in a real-time, dynamic, interactive mode.

The third dimension of the conceptual framework focused on the capability of the instructional medium, CAI. $COLT^2$ instructional strategies will reflect hardware and software capabilities present in the selected CAI system and the operating system available. In short, instructional strategies are delimited by the medium through which the learning is to occur.

The conceptual framework served well as an organizer of the instructional strategy data base. However, there are two deficiencies in the framework. First, the data base does not encompass theoretical and empirical knowledge related to small group behavior which may be applicable to team training instructional strategies. Most important among these would be the process paradigms reflecting the different types of contextually related interpersonal

relationships. Identification of these processes may significantly contribute to the development of evaluation paradigms as part of an instructional system development model for team training. Secondly, while the conceptual framework served well for organizing the data base, it lacked procedural guidelines for translating the data into actual instructional strategies for specific TACFIRE team training problems.

Implementation of a Team ISD Model

Section four contains a description of the design and implementation of the team ISD model for the purpose of the brassboard development. The major components of the approach included job/task analysis, development of team learning objectives, and scenario development inclusive of instructional strategies.

The team ISD model employed in this project has notable strengths and weaknesses. Foremost among its strengths was the efficacy of implementing the job task and training analysis. The analysis methodology based primarily on the work of Glanzer (1961) yielded the discrete tasks comprising the TACFIRE fire mission with both situational context and team structure dimensions identified. The job/task flowcharts developed from this analysis also proved exceptionally efficient as vehicles for translating the job/task and training analysis into training scenarios reflecting not only the task to be performed but also the environmental conditions to be simulated.

The weaknesses of the team ISD model were in two directly related areas. First, a distinct deficiency of the model was revealed in the formulation of team learning objectives. The model lacks the methodology for preparing terminal and enabling objectives and analyzing the objectives by learning category. This deficiency is also related to the lack of evaluation procedures

in the model. More specifically, evaluation of the member acquisition of team skills (i.e., coordinating and cooperative behaviors) is not present.

In summary, the ISD model offers a sound base for developing team instructional strategies and team training. However, the model is not sufficiently detailed to lend itself as an operational or procedural guide for the general production of team training curricula.

PLANIT Implementation

The PLANIT implementation was described in terms of the team training considerations of (1) storage and retrieval of information related to scenario events, communications, learning events sequences, and student performance via the common data base, (2) initialization of lessons, (3) synchronization of team members to scenario events, and (4) communications among team members. Section four describes how these team CAI considerations were matched with the PLANIT team training directives in the development of the team training brassboard. The present discussion will emphasize the problems encountered in the development of the brassboard and potential enhancements of the PLANIT team training version. Among the proposed enhancements will be some considerations for authoring capabilities.

The common data base implemented in PLANIT was adequate for programming the instructional strategies, tracking of events, and synchronization of the subjects to scenario events. The use of the common data base for these purposes involved only a matter of appropriate design of the matrix in PLANIT. However, if team training lessons in the future are to be implemented by Army instructional personnel, then it may be desirable to provide commands with parameters to set the values of the common data base indicating sequences of events, automatic designation of terminal values, and synchronization requirements. It is recognized that to make the matrix a primitive would consume

space and likely add unwanted constraints on author flexibility. However, if the lesson can be designed and coded by an instructor, time savings and cost effectiveness could be realized. One possibility, for example, might be that the author could designate a directive HOLD with parameters indicating the frame labels on which a team member might be held. A HOLD directive parameter would also have to designate the other team members with which the holding action would be compared. Thus, synchronization parameters could be established in a preformed matrix with authoring directives for either sequencing events or holding students.

The PLANIT system could automatically put the frame numbers of these labels in the data base with the designated terminal values for determining which program was operating. When a label was reached and a frame executed, the frame counter for comparison and branching (similar to the use of matrix cell X(3,3,1)) would be automatically implemented. In this way, the burden of building specific synchronization techniques as well as the design of the common data base would be taken off the shoulders of the author.

In the lessons implemented for the study, all content of the communications was canned. That is, the messages were preprogrammed as part of the lesson data base. To allow the student to make up his own message is also possible within PLANIT via student-initiated DIAL directives. In this manner, the student controls the content. This capability was not used in the lessons developed because there are distinct implications for both instructional and evaluation strategies.

For the purpose of the brassboard several instructional strategies for teaching team communications were considered but not implemented because of current PLANIT restrictions. For example, instead of asking an FDO subject to select the appropriate action by number and sending the canned message to

his FDS partner, it was possible to allow a free interchange of DIAL messages between the two. If such a strategy were followed with rules defining the FDO and FDS roles, it might be more beneficial for transfer to the actual target task than the strategy employed. However, at present, there is no capability to record or diagnose such an interchange automatically.

If messages could be stored and searched for key words or phrases, CAI strategies could be employed to diagnose the state and content of communications. This information would allow prompting, interception of messages from one member to another, or branching strategies. Without the capability to store and diagnose the message, the interchange is not only free form but so are the instructional strategeies.

It is also desirable to have PLANIT authoring strategies. Such strategies would have the purpose of providing a framework in which the logical and empirical basis for team training is associated with authoring techniques. In this way the instructional technology of team training can be taken into account. The general design used in lesson building for this study was to sequence lessons according to four levels: (1) individual, (2) beginning team, (3) integrated. and (4) emergent team. These levels may be directly tied to the modes of the CAI team training as each relates to the student characteristics, the instructional objectives, and the instructional strategies. That is, some CAI modes may be more or less appropriate at each level of team training. For example, using the CAI modes listed by Hickey (1968), one might find the match of CAI modes with lesson level as presented in Table 13.

Table 13. Example of Match of Team Lesson Levels With CAI Modes

Lesson Level	CAI Mode
1. Beginning Team	Drill and Practice Tutorial Testing
2. Integrated Team	Socratic Tutorial Simulation Testing
3. Emergent	Simulation Game Learner Controlled Testing

The advantage of an author strategy can be illustrated by describing current scenario implementations common to 'team training' for all branches of the military. The scenarios characteristically begin with simple events with long lead times. As the student progresses through the scenario, events increase in number and difficulty. The instructional strategy usually is drill-and-practice and testing with task (mission) achievement being the only measured outcome. Seldom are tutorial, simulation, learner controlled, or game strategies employed. If $COLT^2$ is to be more than a drill and practice experience, the training scenarios must be rich with team instructional strategies.

Brassboard Demonstration/Evaluation

As described in the preceding section, subjects for the brassboard demonstration/evaluation were 40 Army enlisted men from commands in the Washington area. Eight of the subjects trained on the brassboard in an individual mode; the remaining 32 were placed in two-man teams. One team member randomly was selected to serve as the FDO. The other man was the FDS.

Drill, tutorial, problem complexity in sequencing, and individual feedback strategies were the same for all subjects. The teams, however, worked through the beginning team lesson and selected frames of the integrated and emergent lessons in a coordinated mode. In addition, team debriefings at the conclusion of the lessons were more extensive, with team members being apprised of each other's performance and having the opportunity to discuss future role assignments.

A few minor problems were encountered in the evaluation of subjects. It was not possible to acquire lesson times for the first eight subjects. Minor modifications of PLANIT corrected this problem. Second, the responses made by subjects were not recorded initially. The only record that was stored was the correct response to the item and whether the subject was right or wrong. This resulted in a problem in deriving performance scores as one response choice was a query for information and should have been scored as a neutral response. Again, a minor modification to PLANIT was required to correct the problem.

The conclusions to be drawn from the data collected during the demonstration/evaluation are limited. This is due, for the most part, to the limited number of subjects and to the few problems encountered in the data collection itself. However, comparisons of team and individual subject performance, regression analyses of individual and team scores, and analysis of student attitudes and role perceptions towards the instruction lend themselves to some interesting observations.

A critical question regarding team training is whether or not the types of learning which occur in coordinated training differ from the learning that takes place in individual training. Several outcomes of the evaluation indicate that this very well may be the case and may warrant subsequent

investigation. In the across-lesson performance of the groups, it should be noted that the coordinated training received by FDO and FDS subjects did not appear to substantially increase their individual skills. On the other hand, the team performance on coordinated tasks was better than the IND subjects who were working on the same tasks in an individual mode. In short, it appears that team trained subjects acquire skills other than task proficiency. Moreover, those skills contribute to effective job performance.

A second indication that different, but critical, skills are being learned in the team training environment is derived from stepwise regression analyses of individual and beginning team lesson scores. There is little consistency among independent variables for explaining variance in scores between individual and team contexts. On the other hand, across individual scores, there is much greater stability in the explanation of variance. Further, the correlation coefficient between lesson performance for IND subjects was .48. The correlation coefficient between individual performance and team performance for the FDO subjects was .18 and for FDS subjects, .13. The differences are substantial.

In regard to role perception and attitude, there also were some interesting observations. On all four confidence items, FDO and FDS subjects indicated that they were more confident of the decisions made than were IND subjects. While it is difficult to explain the differences, it appears that the interactive, decision making training resulted in greater confidence in self and other team members. One other point of difference between team and individual role perception relates to the perceived dependence of team structure on mission. Team subjects perceived this dependence to be significantly more important than did individual subjects. Thus, team training may contribute,

to a large degree, to increased awareness of tactical environmental conditions as well as self and other team member competence.

A final remark regarding attitudes is warranted. As stated earlier, many of the subjects favorably commented as to their interest in the lessons. The progressions or levels of training, with their increasing reliance on tactical combat simulation and gaming, seem to stimulate subject motivation and interest. This occurred in spite of the fact that the coordinated lessons ran extremely slow, and subjects did have idle time between frames.

In summary, the results of the initial COLT^2 brassboard demonstration/evaluation support the basic tenets underlying the methodology. Representing the situational context of the job performance is critical to effective team training. Analysis of team structure in the performance of jobs can yield dimensions of team member interactions which may be critical to job/task proficiency yet are distinct from individual proficiency skills. Finally, these separate and distinct team dimensions can be successfully subsumed, along with relevant individual training dimensions, under team instructional strategies. Further research into each of the topics covered in the discussion should lead to clarification of the relationships which exist among the topics and contribute to a comprehensive team ISD model.

RECOMMENDATIONS

The following recommendations are categorized as they relate to the (1) development of a team ISD model, (2) enhancement of the team training version of PLANIT, and (3) team training research requirements.

Recommendations for Developing a Team ISD Model

The implementation of the team ISD model revealed a number of strengths and weaknesses. These were discussed in the previous section. Generally, however, the model is insufficiently fleshed out to serve as a step-by-step procedural guide to the development of team instruction. The following paragraphs contain specific recommendations for addressing the weaknesses of the model.

The conceptual framework for COLT^2 instructional strategies, established in this project, has two major deficiences. First, it does not incorporate applicable knowledge related to small group behavior. Second, while the framework serves well as a vehicle for organizing a *team instructional strategies data base*, it does not lend itself to the specification of actual strategies for a *specific training problem*. Recommendations are:

1. Applicable small group behavior knowledge should be incorporated into the team instructional strategies data base.

2. The potential for developing procedural algorithms which optimally mix the training specifications, trainees, learning activities, and instructional delivery systems should be investigated.

Most important the model did not yield adequate learning objectives representing team training requirements. Consequently, the model does not provide adequate evaluation paradigms for assessment of team skills and measurement of the objectives. That is, while it is possible within COLT^2 to

evaluate individual and team achievement and the procedures for doing so are relatively straightforward, the interactive processes are not assessed. In view of this the following recommendations are offered:

3. Specific directions for preparing team terminal and enabling learning objectives should be developed. Included should be a methodology for appropriately categorizing objectives by types of team learning to occur.

4. Process evaluation paradigms for assessing team interactive behaviors should be investigated in terms of their potential for appropriately being matched with specific team situations as defined by team tasks, team structure, and environmental conditions. To be applicable to $COLT^2$, evaluation models would have to be amenable to PLANIT programming.

Recommendations for PLANIT Enhancements

The operational requirements for a team version of the PLANIT CAI system fell into four categories: (1) a common data base to be used for program control, event tracking, and individual/team record storage and analysis; (2) initialization of common lessons; (3) synchronization; and (4) communications. The following recommendations reflect this categorization.

5. The establishment of a common matrix as a primitive should be considered. Although such an action would constrain the implementation of instructional strategies (i.e., reduce the flexibility of the author to manipulate program logic), there would be considerable gain in facilitation of authoring. Matrix parameters could be set for preprogrammed analysis of individual and team responses in order to dynamically manipulate students and instruction. Predefined matrix parameters would be tied to the following recommendations regarding synchronization and communications.

6. Team lessons require synchronization. Currently the required coordination is available only via development of tailored program logic. A synchronizing directive would reduce the current requirement that the author have extensive knowledge of PLANIT programming techniques.

7. Free text or partial free text communications which are terminal initiated are a desirable feature of $COLT^2$. However, the current PLANIT team version does not have the capability to record and analyze this type of message. This capability is required if student performance analysis and problem diagnosis are to be incorporated in team instructional strategies.

8. Minor modifications in message characteristics are being addressed. Foremost among them are message identification, message length, and queuing considerations. Dr. Charles Frye is presently working on some of these problems.

9. Authoring strategies for COLT^2 should be developed. Such strategies would direct and teach the instructor-author to create instructional strategies which optimally configure student interactions, learning events, and CAI modes available in PLANIT.

Recommendation for Future COLT^2 Research

Given the positive findings of the present study, continued testing of COLT^2 instructional strategies so that their full potential and applicability can be realized is recommended. Specifically:

10. COLT^2 research focusing on the relationships between team personnel composites, performance, and interactions should continue. The proposed research would require an extensive experimental effort in order to establish a data base of discriminant team characteristics. The critical factor then would be to define the relationships of between team characteristics and differential instructional treatments.

11. In order to fully assess the impact of team training, process evaluation models that track team member interaction and identify non-task proficiency skills should be investigated. Thus, types of team interactions and 'team skill' acquisition could be related to task achievement within environmental and team structure contexts.

12. Further research on the effectiveness of presenting team training by levels related to tactical complexity and evolutions is certainly required given the promising trends found in the present study. In addition, such an investigation should focus on determining if learning stabilizes across mixes of individual and team instruction. Positive findings would significantly impact on both computer-based and noncomputer-based team training.

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